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TWO IMPORTANT PINE CONE RUSTS AND THEIR NEW CRONARTIAL STAGES

Part 1. *Cronartium strobilinum* (Arthur) Hedgc. and Hahn, comb. nov.

GEORGE G. HEDGCOCK AND GLENN GARDNER HAHN

WITH PLATES V AND VI

The Florida pine cone rust hitherto known in the literature as *Caeoma strobilina* Arth. was described by Arthur[1] from diseased cones of *Pinus palustris* Mill., received from P. H. Rolfs, Palatka, Florida. In the aecial stage this fungus has been known in this state since 1892, when it was collected for the first time by Mr. W. T. Swingle. The distribution of the rust not only includes Florida, where it occurs abundantly in certain localities, but also the neighboring state of Mississippi.[2] At this writing a field survey is incomplete and there is no definite data to show exact distribution, and whether the rust is spreading in the southern states. Frequently the disease has a very damaging effect on the reproduction of the species of pines upon which it occurs. In May, 1919, a count was made of the diseased cones of *P. heterophylla* (Ell.) Sudworth (*P. caribaea* More.) and *P. palustris* over two acres at Dunedin, Florida, and the approximate number of infected cones per tree varied from 25 to 90 per cent. of the total cone crop. This particular year the disease was very common from Palatka and Lake Butler to Tampa. In certain localities where the rust occurs, reproduction of the two pine species common in Florida is very scant. This continuous destruction of the seed crop each year cannot fail to be a hindrance to reforestation; therefore the pine cone rust must be considered as a limited but very important disease.

[1] Arthur, J. C. New species of Uredinieae—V. Bull. Torrey Bot. Club **33**: 519–520. 1906.

[2] The senior writer noted the occurrences of what appeared to be the mature aecial stage of this pine cone rust at a number of points along the coastline of the A. C. L. R. R. in Georgia in May, 1919, but no collections were made. Also observations of persistent mummy cones were made March, 1915, at Dothan, Alabama.

DESCRIPTION OF THE DISEASE

The immature first year cones become infected at an early stage in their development, and within two or three months after they emerge many often exceed the size of the second year uninfected cones (Pl. V, fig. A) borne on the same tree. So far observations do not include infection of these two year old healthy cones. During the first of March many infected scales bearing pycnia may be observed accompanied by immature aecia within the cortical layers of the cone scale tissue immediately beneath. With the maturity of the parasite, the infected cones have become abnormally enlarged and each individual swollen scale has a reddish color which is at first an orange chrome, becoming later a Sanford's brown or chestnut.[1] With the rupturing of the aecial cavities and the sloughing off of the diseased cone scale tissue above, powdery masses of cadmium yellow spores are laid bare, (Pl. V, fig. B,) which entirely cover the cone. Excessive hypertrophy results, and the cones present a large swollen mass or gall, externally still showing the identity of each individual scale, but in longi-section, showing partial fusion of the scales.

In the spring the presence of the young infected cones bearing pycnia can be detected in the tops of tall trees by the presence of nectar-loving insects which have been observed to feed on the pycnial exudations. Later the diseased cones are attacked by insects. One of these which is commonly associated with infected cones is *Dioryctria abietella* D. & S.[2] By autumn the diseased cones have all died and most of them fallen to the ground. Here and there a mummy cone remains indicating the presence of the disease.

ARTIFICIAL INOCULATIONS

Search for the alternate stage of the so-called *Caeoma strobilina* was made by Hedgcock for three successive seasons. The only rust found commonly associated with the Caeoma in pine cones was a Cronartium which wintered over on the evergreen oaks. In a previous publication[3] this overwintering habit was attributed to *Cronartium cerebrum* (Peck) Hedgc. and Long. In view of our present knowledge of the rust, we now know that this overwintering fungus was largely the cone rust fungus. As to the exact amount of overwintering of *C. cerebrum*, the writers are not prepared to state at this time.

[1] Colors used are those of Ridgway, R., Color Standards and Nomenclature, Washington, D. C., 1912.

[2] Identification made by Dr. A. D. Hopkins, Bureau of Entomology.

[3] Rhoads, A. S., Hedgcock, G. G., Bethel, E., and Hartley, C. Host relationships of the North American rusts, other than the Gymnosporangiums, which attack conifers. Phytopathology **8**: 315–316. 1918.

In connection with the above mentioned field observations artificial inoculations were made in the Pathological Greenhouses, Washington, D. C. Inoculations with a given strain of the fungus from a given host and locality were made upon healthy, uninfected plants with all aseptic precautions. These plants were then isolated in separate greenhouses or separate compartments made of cheesecloth upon the side benches of the greenhouse. In no instance were strains of the rust ever mixed. In making observations a single strain was examined upon a given day. All precautions were taken to guard against any possible contamination of an isolated strain.

On March 26, 1918, fresh aeciospores of *Caeoma strobilina* from cones of *Pinus heterophylla* collected at Dunedin, Florida, March 20, were used in inoculating the leaves of two oak trees, *Quercus gambelii* Nutt. and *Q. prinus* Linn. in a moist chamber. On April 11, numerous mature uredinia of a Cronartium[1] appeared on the leaves of both trees. A second inoculation with the same aeciospore material mentioned above was made April 4 on the leaves of a number of oak trees, and on May 18 abundant mature uredinia of a Cronartium were present on the following trees: 2 *Quercus coccinea* Muenchh., 5 *Q. gambelii*, 1 *Q. phellos* Linn., 1 *Q. prinus* and 1 *Q. virginiana* Mill. A third inoculation was made on oak trees May 14 with fresh aeciospores sent from Dunedin, and June 1 the following trees were infected, bearing mature uredinia: 4 *Quercus coccinea*, 2 *Q. emoryii* Torr., 4 *Q. gambellii*, 1 *Q. michauxii* Nutt., 3 *Q. minor* (Marsh) Sargent, 1 *Q. palustris* Muenchh., 1 *Q. phellos*, 4 *Q. platanoides* (Lam.) Sudworth, 1 *Q. rubra* Linn., 3 *Q. velutina* Lam. and 2 *Q. virginiana*.

Pedigreed urediniospores from the preceding experiments were used to propagate and continue the growth of the rust on oak trees for the remainder of 1918 and in 1919. Only one of the trees originally inoculated, a tree of *Quercus virginiana*, which did not shed its leaves, carried the rust through the winter of 1918–1919. Two leaves of this tree bore a few telia of a Cronartium which were mature about December 15, 1918.

In 1919 fresh aeciospores were obtained from *Pinus heterophylla* and *P. palustris* at Dunedin,[2] Florida, and from these strains inoculations were made independently and apart from those of the previous year's rust strains. The results obtained were similar to those of the previous year. With these pedigreed strains from 1918–1919 aeciospores, trees of the following additional species in 1919 were infected successfully, bearing urediniospores: 1 *Quercus alba* Linn., 4 *Q. dentata* (Marsh) Borkh.,

[1] These, owing to the inconspicuous peridium were at first assumed to belong elsewhere than to Cronartium. See Phytopathology **8:** 338, 1918.

[2] No stem Peridermium of any species was found present in or near Dunedin during a survey of three years.

Q. geminata, 2 *Q. gunnisonii* (Torr.) Rydb., and 10 *Q. robur* Linn. From the pedigreed 1918 strains the following bore the telia of Cronartium: 1 *Quercus robur*, and 5 *Q. virginiana*, from the 1919 strains, 1 *Q. minor*, 1 *Q. rubra*, and 5 *Q. virginiana*.

In 1920 and 1921, further aecial and uredinial inoculations were made confirming the work of the preceding years, many dark telia of Cronartium being formed on the leaves of the infected trees from December, 1920, to March, 1921. No telia were formed in any of the experiments during the period from April to November.

During four years' experimentation the number of trees of each species successfully infected and bearing uredinia are as follows, the number in parenthesis indicating the number of trees bearing telia: 16 *Castanea dentata* (Marsh) Borkh., 5 *C. pumila* (Linn.) Mill., 5 *C. sativa* Mill., 36 *Quercus agrifolia* Née, 9 *Q. alba* Linn., 1 *Q. californica* (Torr.) Coop., 6 *Q. cerris* Linn., 12 *Q. coccinea* (2), 27 *Q. dentata*, 18 *Q. emoryii* (4), 18 *Q. digitata* (Marsh) Sudworth, 7 *Q. douglasii* Hook & Arm., 50 *Q. gambelii*, 11 *Q. geminata* (3), 13 *Q. gunnisonii*, 6 *Q. imbricaria* Michx., 3 *Q. lobata* Née, 5 *Q. macrocarpa* Michx., 5 *Q. michauxii*, 6, *Q. minor* (1), 5 *Q. palustris*, 3 *Q. phellos*, 7 *Q. platanoides*, 1 *Q. prinoides* Willd., 16 Q. *prinus*, (1), 14 *Q. robur* (4), 12 *Q. velutina*, and 37 *Q. virginiana* (17). We have successfully infected with this rust every species of Castanea that we have tested. *Quercus virginiana* and *Q. geminata* in the greenhouse as well as in nature are the best telial hosts.

Inoculations with fresh aeciospores collected from *Pinus heterophylla* Dunedin, Florida, were made March 26, 1918, as follows: 4 first year cones of 2 *P. pinaster* Ait. were inoculated by inserting aeciospores in wounds beneath the epidermis, and closely wrapping with moist cotton; 6 first year cones were inoculated by placing aeciospores upon the surface of the cones, and then similarly wrapping with moist cotton. Negative results were obtained in both cases.

Inoculations with teliospores were made in a number of pine trees in 1919 and 1921, by placing telial columns in incisions under the bark of rapid growing shoots, and tightly wrapping the wounds with moist cotton. Negative results have been obtained to date. Trees as follows were used: 9 *Pinus heterophylla*, 1 *P. clausa* (Engelm.) Sarg., 30 *P. radiata* Don., and 2 *P. taeda* Linn. Inoculations similarly made in other experiments with the telia of *Cronartium cerebrum* (Peck) Hedgc. and Long, and *C. fusiforme* (Peck) Hedgc. and Hunt, have given a high percentage of infection both for 1919 and 1921 inoculations.

The above investigations made by the writers[1] 1915–1921 now clearly

[1] N. Rex Hunt should be credited with part of the earlier studies and culture work at Washington, D. C., in 1918.

show that *Caeoma strobilina* is a true Peridermium with definite peridia belonging to a Cronartium occurring on deciduous and evergreen oaks. We therefore transfer *Caeoma strobilina* Arth. to the genus Cronartium with the following description:

CRONARTIUM STROBILINUM (Arthur) Hedgc. and Hahn, comb. nov.

Syn. *Caeoma strobilina* Arthur, Bull. Torr. Bot. Club **33**: 519, 520, 1906.

O. Pycnia[1] conicolous, preceding the aecia the same season,[2] arising in the infected reddened cone scales in sub-epidermal ellipsoid areas which finally coalesce into a more or less broken layer, 90 to 380 μ deep, averaging 200 μ; pycnial exudate deep chrome to yellow ochre; pycniospores obovoid to ellipsoid, hyalin, 2 to 2.5 μ by 2.5–3.5 μ. averaging 2.2 by 3 μ.[3]

I. Aecia conicolous, forming in hypertrophied scales, in deep seated sub-corticular ellipsoidal areas (Pl. V, fig. C) several layers of cells (6 to 14) beneath the pycnial layer which finally coalesce into a more or less broken layer within the cortex of the cone-scales; peridium in a definite multiple layer; peridial cells[4] (Pl. V, fig. D) at the top of the sorus. are usually more rounded than those at the sides; for the latter tend to become pulled out or elongated. Therefore the size of the cells varies widely, 10–20 by 10–45 μ. The mature wall is 3–5 μ thick, averaging 4 μ; outermost wall being smooth and inner cell wall verrucose with short tubercles which in clumps tend to give the cells the appearance of meshing or dove-tailing together. The protoplasmic contents of the peridial cells stain very lightly as compared with the aeciospores. Fre-

[1] The pycnia are described from F. P. No. 25179 *Pinus heterophylla*, Dunedin, Fla., March 20, 1918; and the aecia from F. P. No. 22747 from *Pinus palustris*, Fruitland Park, Fla., May 8, 1918.

[2] The pycnia of this species are unique because they differ from other known species of Cronartium, in that they are formed the same season in the same tissues as the aecia but mature earlier. Pycnia formed a short time before the aecia which lie beneath are separated from the latter by several layers of cortical cells.

[3] The size of sori in this description are based on not less than 50 measurements, and of spores on not less than 100 measurements.

[4] The peridium of *Cronartium strobilinum* in the aecial stage is unique with regard to its formation. Due to the deep seated origin of the aecial area, the peridial layer never becomes extruded from the cone scale (Plate V, fig. C) tissue, but always remains more or less deeply buried beneath the cortical layers above. With the sloughing off of these cortical layers above the aecium, the peridium falls away at the same time with these outer tissues, leaving the base of the aecium apparently without a peridium. Sections of the immature rusted cones readily show this peridium, the cells of which can be readily identified as peridial cells by their position, shape, and cellular content.

quently these cells are merely empty shells. Fresh aeciospores in mass are cadmium yellow to capucine yellow; aeciospores obovate to ellipsoid, rarely globoid, often attenuate below, 12–20 by 17–31 μ, averaging 15 by 25 μ, walls 3–5 μ thick, averaging 3 μ, verrucose with small tubercles 1.5 to 2 μ in diameter and with a smooth area, extending from the thickened base up one side.

II. Uredinia[1] hypophyllous, rarely epiphyllous, subepidermal, sometimes internal, at first from a limited mycelium, but later spreading; infected areas become brightly colored, sal non orange to grenadine red; sori produced continually throughout the year, both in the field and in the greenhouse, wintering over upon the leaves of evergreen oaks; sori sphaeroid to ellipsoid, rupturing at the top of the dome. Peridia delicate, evanescent; formed by a layer of cells which adheres to neighboring homologous cells (Pl. V, fig. E) and which gradually separates from the underlying urediniospores (Pl. V, fig. F). With the maturity of the urediniospores, the peridium is forced up into the dome, resulting in the loss of outline and regular shape of the peridial cells which become exceedingly flattened, and almost indistinguishable (Pl. V, fig. G) when the sorus is ruptured. Urediniospores, cadmium yellow in mass, globoid to ovoid or ellipsoid, 12–18 by 15–26 μ, averaging 15 by 20 μ; walls colorless, 1.5–3 μ thick, averaging 2 μ, echinulate with low, inconspicuous, conical papillae, 1.5–2 μ in diameter.

III. Telial columns hypophyllous rarely epiphyllous, filiform, mummy brown to black, 1.5–3.8 mm. in length, averaging 2.6 mm., 70 to 190 μ in diameter, averaging 110 μ; teliospores fusiform-oblong to fusiform, 10–20 by 20–45 μ averaging 15 by 30 μ, walls 3–6 μ averaging 4 μ, smooth, brownish.

COLLECTIONS

Cronartium strobilinum according to our records has been collected as follows:

I. On *Pinus heterophylla*: Florida—Altoona, by W. T. Swingle, May 31, 1892[2]; Orange Bend, June 4, 1892; Dunedin, S. M. Tracy,[3] June 20,

[1] The uredinia are described from type specimen F. P. No. 32454, and the telial columns from type specimen F. P. No. 38015, *Quercus virginiana*, Pathological Greenhouses, Wash., D. C., grown from aeciospores under controlled conditions. The type specimens are deposited in the Pathological Collections, U. S. Dept. of Agr., Wash., D. C.

[2] Pathological Collections, U. S. Dept. of Agr.

[3] Arthur, J. C., New Species of Uredineae V, Bull. Torr. Bot. Club **33**: 519, 1906. Through the courtesy of Prof. Arthur, the writers have been permitted to examine and compare the specimens cited in this paper.

1921, (wrongly determined as *Pinus taeda*), G. G. Hedgcock, March 20, and May 8, 1918, March 5, and May 17, 1919; Lake City, by P. H. Rolfs,[2] May 30 and July 10, 1906 (wrongly determined as *Pinus taeda*); Florence Villa, by S. F. Poole, April 25, 1913; Eustis, by W. H. Savage, June 1, 1914, and by G. G. Hedgcock March 25, 1918, also Leesburg, March 8 and 26, 1918; Tampa, March 7, 1919; Gainesville, May 14, 1919. Mississippi—Agricultural College, by J. M. Beal, May 10, 1915; Hattiesburg, by J. W. Champlin, May 15, 1919.

On *Pinus palustris*: Florida—Altoona, by W. T. Swingle, June 1, 1892; East Palatka by P. H. Rolfs, May 30, 1906; Gainesville, by H. E. Stevens, May 23, 1914, and by G. G. Hedgcock, May 14, 1919; Fruitland Park, by L. P. Bosanquet, June 19 and 30, 1916, and June 1, 1918, and by G. G. Hedgcock, March 3, 1918; also Dunedin, March 20 and May 8, 1918, March 5, and May 17, 1919; Tampa, March 21, 1918, and March 7, 1919; Leesburg, March 26, and May 7, 1918, and May 8, 1919; Weirsdale, March 10, 1919; and Brooksville, May 16, 1919; Alton, by T. S. Tramel, May 12, 1921.

Cronartium strobilinum so far as is known at present has its aecial stage on the cones of only two species of pine, *Pinus heterophylla* and *P. palustris*.

II, III. On *Q. geminata*: Florida—by G. G. Hedgcock, West St. Augustine, March 4, 1915; Sopchoppy, April 3, 1915; Worthington Springs, March 29, 1918; Lake City, March 30 and 31, 1918 and March, 12, 1919; Gainesville, February 25, and May 14, 1919; Silver Springs, February 27 and May 15, 1919; Ocala, February 28, 1919; Brooksville, March 4, and May 16, 1919; Tampa, March 7, 1919; Leesburg, March 8, 1919; Jasper, March 13, 1919; Dunedin, March 5, and May 17, 1919, also by W. H. Long, January 21, 1919.

On *Quercus virginiana*: Florida—by G. G. Hedgcock, Brooksville, March 3 and 4, 1919; Weirsdale, March 10, 1919; Gainesville, May 15, 1919; Dunedin, March 5, 1919; also by W. H. Long, January 21, 1919. Cuba—San Diego de Los Baños, by J. R. Johnston and C. H. Ballou, March 25, 1921.

On *Quercus nigra*: Florida—Gainesville, by G. G. Hedgcock, February 25, 1919.

Specimens have been also collected from artificial inoculations at Washington, D. C., on nearly all the species of chestnut and oak used in the experiments given in the preceding pages of this paper.

In Florida, either *Quercus geminata* or *Quercus virginiana*, or both are always found in close association with pines infected with the cone rust. From this it is predicted that the range of *Cronartium strobilinum* will be limited to the natural range of these two telial hosts, since infected deciduous hosts shed their leaves before telial formation.

In the greenhouse at Washington, D. C., leaves of deciduous species of Castanea and Quercus, inoculated during the period from March to June, fail to produce telia because they shed their leaves normally before the time of telial production takes place. By cutting back trees and forcing them to renew their foliage so that they can be inoculated from July to December, telial formation is secured during the winter months. In evergreen species, cutting back is not necessary to secure telial production. The maximum period of telial formation in the greenhouse is during the months of December and January. Although observations have not been made, this period must coincide with what takes place in the field in order that the young cones may become infected at this time or shortly afterwards, with the result that pycnia are produced the latter part of February and the first of March.

Part II. *Cronartium conigenum* (Pat.) Hedgc. and Hunt, comb. nov.

GEORGE G. HEDGCOCK AND N. REX HUNT

Patouillard[1] in 1896 described the new species *Caeoma conigenum* on the hypertrophied cones of an undetermined species of pine from a specimen collected by Maury in Mexico, June, 1891. He published a picture of a diseased and a healthy cone of what is undoubtedly *Pinus chihuahuana* Engelm. The photograph from which the plate was prepared was taken by Maury and sent with the type specimen to Patouillard in France. Although Patouillard describes a Caeoma, a Peridermium with cerebroid aecia is shown in figure 2 of his plate. The type specimen was sent a long distance and may have lost evidences of the peridium in transit. Through the courtesy of Prof. J. C. Arthur and of Dr. F. J. Seaver, the writers have examined two fragments of the type. The specimen from Prof. Arthur's collection shows an aecial layer and no distinct peridium but peridial cells were found among the aeciospores. The piece of the specimen sent by Dr. Seaver from the collections of the New York Botanical Garden also possessed an aecial layer and distinct traces of a peridium, proving that *Caeoma conigenum* Pat. is morphologically a Peridermium.

In recent years a number of collections of a pine-cone rust have been received by the writers from Arizona. The earlier collections were badly weathered, did not show a distinct peridium, and were assigned to *Caeoma conigenum*.[2] Later specimens possessed aecia with distinct

[1] Patouillard, N. Note sur un cone de pin dèformè par une urèdineè. Jour. de Botanique **10**: 386–388, *Pl. IV*. 1896.

[2] Hedgcock, Geo. G. Notes on some western Uredinia which attack forest trees. Mycologia **4**: 146, 1912.

erumpent, occasionally cerebroid peridia.[1] House receiving one of the specimens with cerebroid aecia identified it as *Peridermium cerebrum* Peck[2] and published a very fine illustration of it.

The junior writer in an investigation of this cone Peridermium in the vicinity of Portal, Arizona, in May, 1918, found both the fresh uredinial and mature telial stages of a species of Cronartium apparently wintering over very sparsely on the leaves of the evergreen oaks *Quercus emoryi* Torr. and *Q. hypoleuca* Engel., and occurring even more abundantly on the fallen leaves of the same species, and closely associated with trees of *Pinus chihuahuana*. The latter bore weathered cone-galls which had evidently fruited the previous year, since there were present abundant remnants of aecia, giving them a grayish color. The uredinia and telia were found at least two months before the time of maturity for the aecia on the cone-galls, which is July to August. No stem form of Peridermium was found in 1918 on the pines present in this region (*Pinus chihuahuana*, *P. apacheca* Lemm., and *P. cembroides* Zucc.), although hundreds of trees were closely examined, nor has any other species of Peridermium ever been to our knowledge reported from this region. This Peridermium evidently infects the cones of *Pinus chihuahuana* during the first year of their growth. As a result of infection, cones develop into galls having a slight differentiation of the surface into scales and very little resemblance to a true cone. The immature galls are usually two or more times as large as cones of the same age (Pl. VI, figs. A and B) and regardless of size may be sliced up with a knife much more readily than healthy cones. After fruiting the galls dry up and may remain on the trees as mummies. The interior of these mummies is almost always nearly destroyed by insects, so that little more than a brittle shell remains after a couple of months. A striking feature of the disease is the great variation in the size of the galls, the largest having a volume ten times that of the smallest. Most of the galls are of the smallest size and evidently fruit within two years after infection, as shown by the age of the nodes bearing them, while the medium sized galls fruit (at least in part) within three years. The age, at the time of fruiting, of the largest galls was not determined, partly because insects usually kill them before they fruit and partly because they had invariably stopped the normal elongation of the branches bearing them. In fact such galls, even though not yet mature, almost always terminate the branches bearing them. Before fruiting, these largest galls have a much

[1] Hedgcock, Geo. G. and Hunt, N. Rex. Notes on some Uredinales attacking pines. Phytopathology **9:** 53, 1919.

[2] House, H. D. *Peridermium cerebrum* Peck. Rept. New York State Botanist or 1914. Museum Bull. 179: 36, 37. *With plate.* 1915.

smoother surface than the smallest ones. Remains of the aecia are very evident on some cones for a year or more after sporulation. The finding of galls with the remnants of what appeared to be the aecia of two different years led to the unconfirmed suspicion that some galls might fruit for more than one season.

The economic importance of this cone disease cannot be determined without considerable study. Counts of diseased and healthy cones on several groups of trees showed that more than fifty per cent of the cones were infected in some groups, while on many individual trees as high as ninety per cent were infected. In addition to the diminution of seed production, the disease stunts or terminates the growth of many limbs so that infected trees are apt to present a very ragged appearance. Although only one small region has been surveyed, it seems quite possible that under favorable conditions this Peridermium might cause a dangerous disease, especially in northern Mexico where *Pinus chihauhuana* is of greater commercial importance.

ARTIFICIAL INOCULATIONS

The senior writer[1] has made inoculations with the aeciospores of this pine cone rust on *Pinus chihuahuana* from Arizona in greenhouses at Washington, D. C., as follows:

Immature aeciospores from unopened aecia on cones collected in the Chiricahua Mountains by A. H. Zachau of the Forest Service June 11, 1914, were inoculated without infection on 8 oak trees, viz., 2 *Quercus coccinea* Muenchh., and one each of *Q. arizonica* Sarg., *Q. emoryi*, *Q. michauxii* Nutt., *Q. minor* (Marsh) Sarg., *Q. palustris* Muenchh., and *Q. virginiana* Mill., without any infection. July 9, 1914, aeciospores from the same source were used to inoculate 5 trees of *Pinus virginiana* Mill., and 1 *P. rigida* Mill., by inserting masses of spores under the bark of growing shoots and wrapping the wounds closely with wet cotton, also without infection.

July 30, 1918, leaves of 39 oak trees were inoculated with fresh aeciospores collected by A. J. Abbott of the Forest Service near Portal, Arizona, July 26. Of these 6 trees became infected and bore the immature uredinia of a Cronartium in 10 to 12 days. One each of the following species were infected: *Quercus palustris*, *Q phellos* Linn., *Q. prinus* Linn., *Q. rubra* Linn., *Q. velutina* Lam., and *Q. virginiana*. Some of the uredinia remained on the leaves until November, but owing to the shedding of the leaves no telia were formed.

[1] During 1920 and 1921 he was assisted by Glenn G. Hahn.

July 20, and July 30, 1920, leaves of 81 oaks trees were inoculated with aeciospores from cones collected by Otto Schoenberg of the Forest Service near Portal July 14, 1920. The following became infected, bearing the mature uredinia of a Cronartium in 10 to 15 days: 2 *Quercus agrifolia* Née, 1 *Q. coccinea*, 4 *Q. douglasii* Hook & Arn., 2 *Q. gambelii* Nutt., 1 *Q. geminata*, 5 *Q. robur* Linn., and 1 *Q. rubra*. In this experiment the following chestnut and chinquapin trees were inoculated: 3 *Castanea dentata* (Marsh) Bork., and 1 *C. pumila* (Linn.) Mill. The leaves of the tree of *Q. geminata* had chlorotic spots indicating infection, but no uredinia were produced. At the same time the following pines were inoculated in the same manner as those in the experiment in 1914: 4 *Pinus heterophylla* (Ell.) Sudw. (*P. caribaea* More.), 4 *P. radiata* Don. and 2 *P. taeda* Linn. These are as yet without an apparent infection.

During 1920 and 1921, by using urediniospores from the preceding set of inoculations, many trees of oak, chinquapin and chestnut were inoculated, a number of which bore the telia of a Cronartium during the winter months from November to February, thus fully proving that this pine cone Peridermium belongs to the genus Cronartium. The following list gives the number of trees of each species successfully inoculated and bearing uredinia, the number bearing telia given in parentheses: 11 *Castanea dentata*, 9 *C. pumila* (1), 5 *C. sativa* Mill., 16 *Quercus agrifolia*, 9 *Q. alba*, 3 *Q. coccinea*, 15 *Q. cerris* Linn., 6 *Q. douglasii* (2), 6 *Q. gambelii*, 1 *Q. imbricaria* Michx., 14 *Q. macrocarpa* Michx., 1 *Q. marilandica* Muenchh., 5 *Q. minor* (Marsh) Sarg., 7 *Q. palustris* (1) 1 *Q. platanoides* (Lam.) Sudw., 9 *Q. prinus*, 32 *Q. robur* (6), 7 *Q. rubra*, 5 *Q. velutina* (1) and 1 *Q. virginiana*. An equal number of trees were used as controls in the experiments given in this paper, and all remained free from the rust. Trees when inoculated were placed for a period of 2 to 3 days either in enclosed glass walled damp chambers or in iceless refrigerators,[1] the latter giving the best results. After inoculation, the trees were kept in rooms or compartments of the greenhouses separate from trees inoculated with other species of Cronartium.

We consider *Caeoma conigenum* identical with this Arizona pine cone rust for the following reasons: Patouillard's illustration of a diseased cone agrees with the appearance of weathered cones diseased with the Arizona rust in which the aecia have broken through the outer layers of the cone tissues. His measurements for the aeciospores, 12–20 by 25–40 μ, and our measurements (based on 100) of the same from two

[1] Hunt, N. Rex. The "iceless refrigerator" as an inoculation chamber. Phytopathology **9**: 211–212. May, 1919.

fragmental type specimens, 14–21 by 24–50 and 12–21 by 18–41 μ, fall well within the range obtained by us for those of the Arizona rust, viz., 12–25 by 19–51 μ. The peridial cells found in the type specimens agree closely in size and shape with those present in the Arizona rust. We now transfer *Caeoma conigenum* to the genus Cronartium with the following description:

CRONARTIUM CONIGENUM (Pat.) Hedgc. and Hunt comb. nov.

Syn. *Caeoma conigenum* Pat., Jour. de Bot. **10**: 386–388, Pl. IV, 1896.

O. Pycnia[1] in lenticular, subepidermal areas, either preceding the aecia by one growing season, or occurring on different areas of the same cone scales later in the same season as the aecia. Pycnospores obovoid.

I. Aecia[1] conicolous, subcorticular, distinct, sphaeroid, or rarely confluent and cerebroid (Pl. VI, fig. B).

Sori firm but not bladdery, 1–5 mm. in diameter, averaging 2.6 mm;[2] peridia circumscissile, soon falling away in flakes, leaving rounded spore masses, and often broken lacerate edges at their margin; peridial cells usually in one to two layers, overlapping, irregularly sphaeroid to clavate or fusiform, basal cells longer and narrower than the apical ones, 14–32 by 28–100 μ, averaging 22 by 56 μ with walls 4–10 μ thick, averaging 6 μ inner walls finely striated with tubercular outgrowths; aeciospores sphaeroid to ovoid or ellipsoid, 12–25 by 19–51 μ, averaging 18 by 35 μ, (Patouillard gives a range of 12–20 by 25–40 μ), with walls 2–5 μ thick, averaging 3 μ, coarsely verrucose with dense, somewhat deciduous tubercles, with a thickened smooth spot at the base.

II. Uredinia[3] hypophyllous, rarely epiphyllous, usually subepidermal, from a limited mycelium, in chlorotic (never reddened) areas of the leaves, single, scattered or clustered, sometimes confluent, irregularly sphaeroidal, rupturing irregularly at the apex; peridium evident but evanescent; urediniospores capucine yellow in mass, fading when old, sphaeroid to obovoid, rarely ellipsoid, 11–25 by 16–36 μ, averaging 18 by 25 μ, with walls 2–5 μ thick, averaging 3 μ, echinulate on the surface.

III. Telial columns hypophyllous, filiform, chestnut to bay, 2.8 to 6 mm. long, averaging 4.3 mm., 70–150 μ in diameter, averaging 112 μ; teliospores oblong to fusiform, 10–23 by 20–50 μ, averaging 16 by 34 μ walls tinged with brown 2–6 μ thick, averaging 4 μ.

[1] The pycnia are described from type specimen F. P. No. 25402, collected by N. Rex Hunt, September 28, 1918, and the aecia from F. P. No. 36152 by Otto Schoenberg August 10, 1920, both on cones of *Pinus chihuahuana* near Portal, Arizona.

[2] The dimensions of sori in this description are based on not less than 50 measurements, and of spores, not less than 100.

[3] The type specimens for the uredinia and telia are F. P. No. 29666 on the leaves of *Quercus hypoleuca* collected by N. Rex Hunt, September 28, 1918, near Portal, Arizona. These and the type for the pycnia are deposited in the Office of Pathological Collections, United States Department of Agriculture, Washington, D. C.

COLLECTIONS OF THE FUNGUS

Cronartium conigenum has been collected according to our records, in Arizona and Mexico as follows:

I. On *Pinus chihuahuana*; Mexico, by Maury in 1891; Arizona, Chiricahua Mountains. by A. H. Zachau, July 10, August 20, and September 2, 1909, also April 24, June 27 and August 27. 1914; Canille, by W. T. Doherty of the Forest Service July 12, 1914; near Portal, by N. Rex Hunt, May 26 and September 28 (Type of pycnia), 1918; also by A. J. Abbott, July 26, 1918, and by Otto Schoenberg, July 22 and August 10, 1920.

II. III. On *Quercus emoryi*; Arizona, near Portal, by A. J. Abbott, August 20, 1918; and by N. Rex Hunt, April 26, and September 28, 1918.

On *Quercus hypoleuca;* Arizona, near Portal, by N. Rex Hunt, September 28, 1918 (Type).

In addition to these specimens, collections have been made from the artificially infected trees of species of oak and chestnut at Washington, D. C., previously mentioned in this paper.

A COMPARISON OF THE MORPHOLOGY OF CRONARTIUM CONIGENUM AND C. STROBILINUM

	C. conigenum	*C. strobilinum*
	Infected cones living two or more growing seasons.	Infected cones dying the first growing season.
I.	AECIOSORI usually distinct and separate.	AESCIOSORI usually becoming confluent and continuous.
	PERIDIUM erumpent, conspicuous.	PERIDIUM submerged, inconspicuous.
	PERIDIAL CELLS 22 by 56 μ[1]	PERIDIAL CELLS 15–35 μ
	AECIOSPORES 18 by 35 μ[2]	AECIOSPORES 15 by 25 μ
II	UREDINIOSORI in chlorotic areas of leaf tissue	UREDINIOSORI in reddened areas of leaf tissue
	UREDINIOSPORES 18 by 25 μ[3]	UREDINIOSPORES 15 by 20μ
III	TELIAL COLUMNS chestnut to bay, 0.11 by 4.3 mm.	TELIAL COLUMNS mummy brown to black, 0.15 by 3.8 mm.
	TELIOSPORES 16 by 34 μ	TELIOSPORES 15 by 30 μ

[1] In this table the average of not less than 100 measurements are given in each instance.

[2] Measurements for the aeciospores of *Cronartium cerebrum* (Peck) Hedgc. and Long, 15 by 26μ, for *C. fusiforme* (Peck) Hedgc. and Hunt, 16 by 25μ.

[3] Measurements for the urediniospores of *Cronartium cerebrum*, 12 by 20μ, and for those of *C. fusiforme*, 13 by 18μ.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

DESCRIPTION OF PLATE V

Fig. A. Size of a first year hypertrophied cone infected with *Cronartium strobilinum* as compared with uninfected cones of the same age. Cones collected from *Pinus palustris*, Dunedin, Fla., 1919. One-half natural size.

Fig. B. Hypertrophied cone showing aeciospore masses of *C. strobilinum* after the cortex above the aecial areas has fallen away. The white flakes or flaps at the apex of the cone belong not to the rust but to a saprophytic fungus growing on the scales of the diseased cone. Specimen F. P. No. 29105, on *P. heterophylla*, Dunedin, Fla., 1918. One-half natural size.

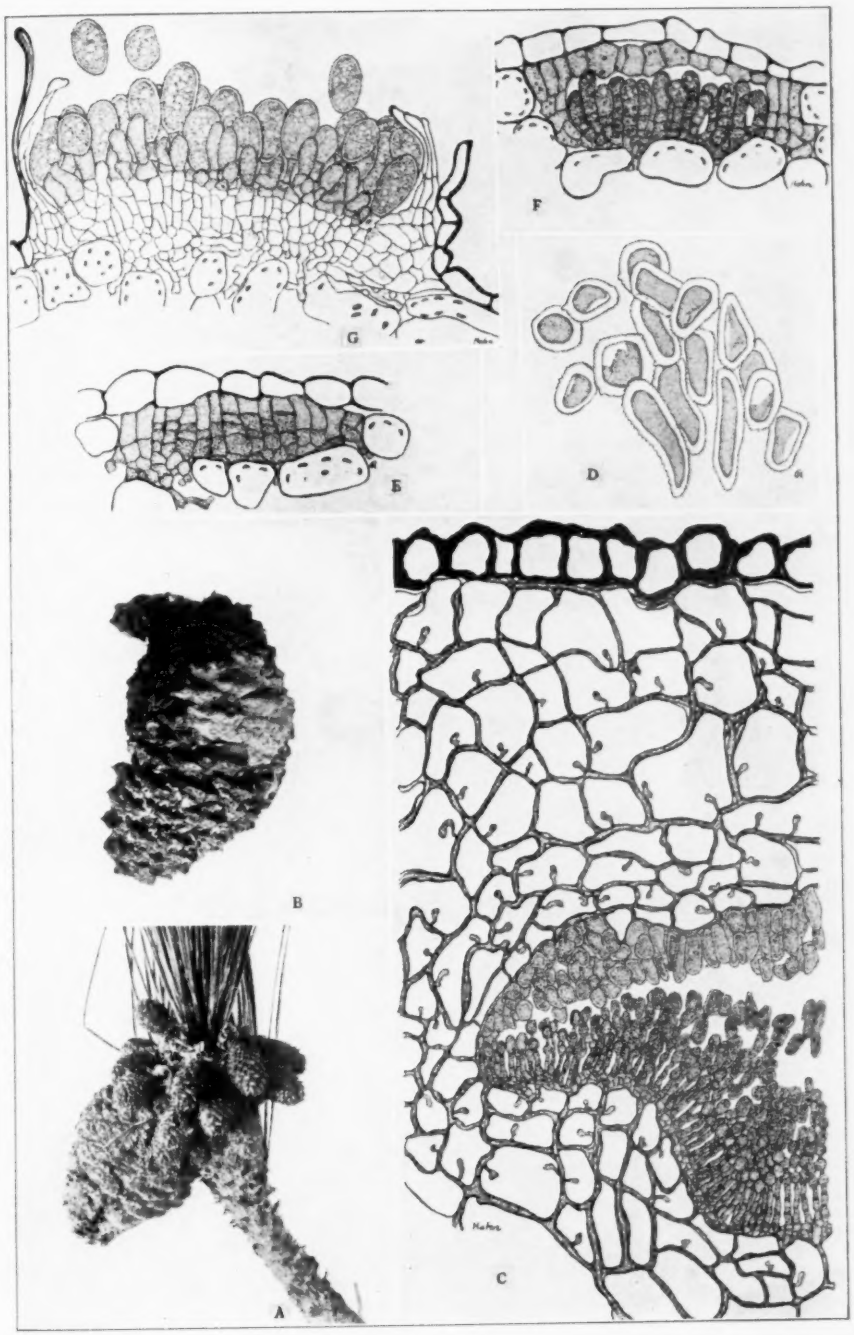
Fig. C. Cross section of a portion of cone scale tissue of *P. palustris* showing the deep seated character of the aecial area of *C. strobilinum*. The peridium, which never becomes extruded, is shown as a definite multiple layer of cells above the aeciospores. Approximately × 180. All drawings made with camera lucida by Glenn G. Hahn.

Fig. D. Peridial cells of *C. strobilinum*, approximately x 400.

Fig. E. Early stages of peridium and urediniospore formation of *C. strobilinum*. Approximately × 400.

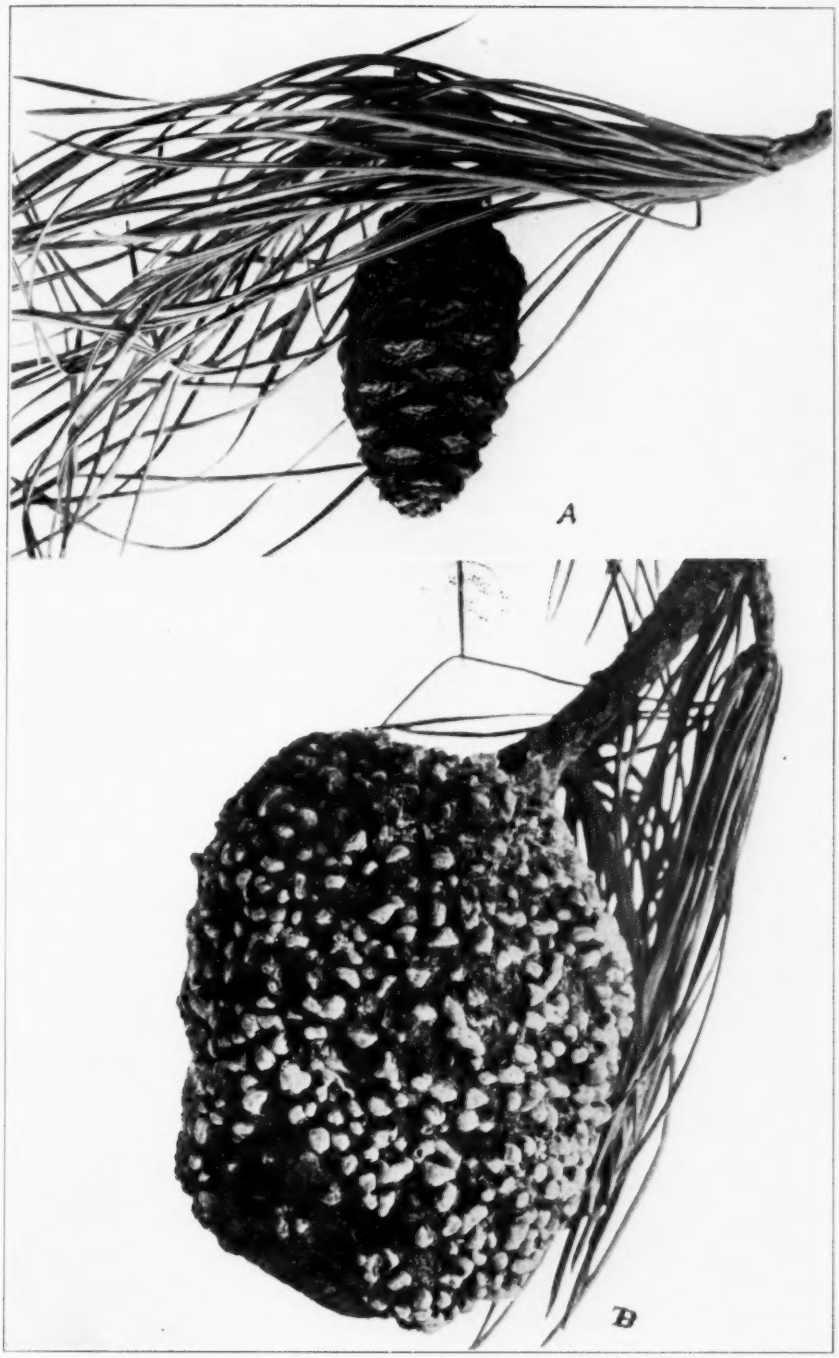
Fig. F. Separation of peridium from developing urediniospores of *C. strobilinum*. Approximately × 400.

Fig. G. Mature uredinium of *C. strobilinum* showing urediniospores and ruptured and shriveled remnants of peridium × 400.



CRONARTIUM STROBILINUM

UNIV. OF MICH.



CRONARTIUM CONIGENUM

Fig. A. An immature two-year old cone of *Pinus chihuahuana*.
Fig. B. A diseased cone of *Pinus chihuahuana* bearing mature aecia.
(Both figures about one-half natural size.)

UNIV. OF MICH.

YELLOW DWARF OF POTATOES

MORTIER F. BARRUS AND CHARLES C. CHUPP

WITH PLATES VII AND VIII AND ONE FIGURE IN THE TEXT

A disease of potatoes probably new to science has made its appearance in New York State. It was first noticed by the senior writer in the summer of 1917 in Green Mountain stock in a field near Cadyville, Clinton County, New York. Only a few hills of diseased plants here and there in the field were observed at the time. They were quite different in appearance from those affected with any other disease he had observed before, the one or two stalks the plants possessed being dwarfed but stocky and the foliage having a marked yellowish tinge. Some of the plants were dying from the top down. On digging into a hill a few small irregular tubers were observed which, on being cut open, revealed a decided necrotic condition of the flesh in the form of rusty specks or areas most pronounced at the bud end of the tuber.

This disease was observed in the same locality the following year and during every year since. At the time of the conference of pathologists on Long Island in June, 1919, the disease was observed at Mattituck in a field of Green Mountains planted with seed obtained from Clinton County. Many of the pathologists present saw the disease there but none of them were acquainted with it. The following year the junior author observed the disease in Warren, Rensselaer, and Washington Counties and it was reported from other localities by members of our staff. At the present time it has been located with certainty in the following twenty counties: Cayuga, Clinton, Dutchess, Essex, Franklin, Fulton, Jefferson, Lewis, Madison, Oneida, Onondaga, Oswego, Otsego, Rensselaer, Saratoga, Steuben, Suffolk, Tompkins, Washington, and Warren (Fig. 1). It appears to be well distributed in the counties to the north and east. The disease has been observed on the following varieties: Green Mountain, Mills Pride, Norcross, Gold Coin, Goldson, Surprise, American Giant, Manistee, Dibbles Russet, Rural Russet, No. 9, Sir Walter Raleigh, Heavyweight, Carmen, White Rose, Burpee's Early, Robson's Seedlings, and Mammoth Prolific. None of these seem to show any degree of resistance.

Plants were found showing all stages of the disease from those on which symptoms were scarcely distinguishable to those very much dwarfed. The most marked characters as seen in the field are the dwarfed condition and yellow color because of which the name "yellow dwarf" was given by Dr. F. M. Blodgett. There are other characters that enable one to distinguish it from other diseases with which it may be confused. The stalks of plants are shorter than those of healthy

plants but have about the same diameter except toward the top where it is greater, giving such plants a stockier appearance. The growing apex dies early and later the axillary buds of the upper part are also killed. The stalk becomes yellowish green in color throughout. A longitudinal section of the entire length of a stalk reveals the presence in the upper portion of rusty colored specks in the pith and cortex at the nodes. In some plants this specking may be found in the tissues of the internodes as well. The specks may be few in number but usually are very abundant in plants in which the disease has progressed to any extent. This discoloration of the cortex often becomes sufficiently pronounced so that it can be observed from the outside through the epidermis. Sections of the axillary and terminal shoots indicate the nature of their death as all tissues are rusty brown and necrotic. These

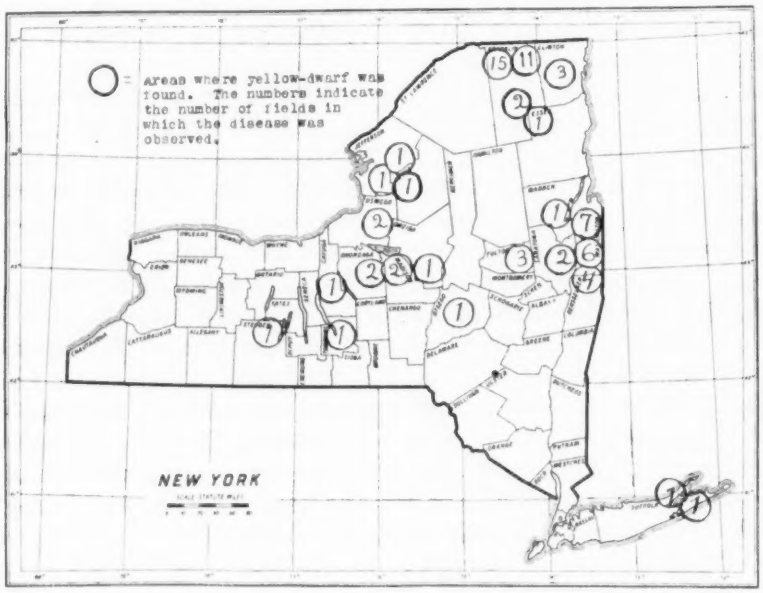


FIG. 1. DISTRIBUTION OF YELLOW-DWARF IN NEW YORK STATE. DUTCHESS COUNTY ALSO SHOULD BE INDICATED.

tissues at the lower part of the stalk rarely show any such discolored areas at any time in the progress of the disease.

The leaflets of affected plants, especially those toward the top, have a tendency to roll upward from the base to the tip and this symptom might confuse the disease with leaf roll were it not for the other symptoms. On blue sprout varieties, such rolled leaflets take on a purplish color where the under surfaces are exposed to direct light. The yellow color predominates as the disease becomes more pronounced until the entire top shows it to a greater or less extent. On some leaves the lower leaflets lose all green color and the yellow takes on a lighter tint

becoming almost white. Affected plants show a greater tendency to tip and marginal leaf burn than do normal ones.

During 1920 the junior author noted in Warren County a type of extreme dwarfing which was not so prevalent during 1921. This absence of dwarfing may have resulted from unfavorable conditions for potato growth during 1921 so that badly diseased plants died before the usual time for inspection. The mature plants were only two or three inches tall, the tops being tufted or rosette-like, while the stems were as thick as those of full grown healthy plants. The leaves were drawn or corrugated as if seriously affected with mosaic, and early began to show the yellow discoloration. This condition might have been mistaken, in some cases, for a type known as curly dwarf were it not for the symptoms present in the tubers.

One could not, however, confuse yellow dwarf with other diseases after examining the tubers. It is true that, in common with leaf roll, affected plants usually produce tubers, small and few in number (Pl. VII, fig. 1). Very commonly, too, these are sessile or are formed on short stolons (Pl. VIII, fig. 1). Occasionally the tubers are irregular, sometimes knobby and cracked, sometimes large and smooth tubers are produced (Pl. VII, figs. 2, 3). The cracked condition is very characteristic of the disease. The cracks first appear in the sides of the tuber and later may extend from one end to the other (Pl. VII, fig. 4). Often several cracks occur radiating from the bud end. They have the appearance of being due to a greater growth within the tuber than was taking place on the outside. That a stress actually exists within affected tubers before cracks appear is shown by the readiness with which such tubers will split open when a knife is stuck into them. Sometimes the cracking occurs near the middle and extends longitudinally up and down. The depth of the cracks varies but commonly they extend inward five mm. or more. The exposed area usually becomes covered with a corky layer before harvest so that loss of moisture is prevented as well as infection from rot producing organisms through these wounds. Occasionally cracks may be found in the interior of the tuber, especially tubers that have been in storage. This shows as a hollow area of greater or less extent.

Another character of the tubers affected with this disease that may be depended on in diagnosis is the discoloration of the flesh. This usually appears as rusty brown specks or areas surrounding the pith area but occurring more or less throughout the surrounding medullary regions or perimedullary tissue and in the cortex. These specks or areas are few and scattered in some tubers and numerous or massed in others but such discoloration does not appear as streaks. Longitudinal sections of the tuber show that the discolored areas are most pronounced

at the middle and often occur nearly to the bud end of the tuber, but they are usually absent at the stem end as seen from an examination of tubers in the field, differing in this particular from wilt diseases. Sections of tubers taken from storage show that the discolored areas occasionally occur nearly or quite to the stem end (Pl. VII, figs. 2, 3).

Not all tubers from affected plants show internal discoloration. Occasional tubers have been found in which there is no marked appearance of an abnormal condition either externally or internally. Sometimes tubers are found that show only one or a few small grayish-brown spots in the cortical region. One farmer, who said he had known the disease to exist in his fields for ten years at least, was able to sort out affected tubers from his bin without cutting them even when they appeared normal in size and shape. "They look different," he said, and a careful comparison of such tubers with healthy ones of the same variety indicated a greater prominence of the lenticels of affected tubers. This condition, however, is not sufficiently marked to attract attention unless a comparison is made.

When one or more shoots of a hill are healthy and others of the same hill are affected the tubers attached to the healthy shoots, occasionally at least, are also healthy while those attached to the affected shoots are usually diseased, so that healthy and affected tubers may be found in the same hill (Pl. VII, fig. 2).

The seed piece has nearly always been found intact in the case of yellow dwarf plants that have been observed in the field. This condition of the seed piece has also been reported as of common occurrence with leaf roll plants. Tubers distinctly affected with yellow dwarf when planted in the greenhouse and out of doors have usually decayed but this may be due to the more advanced stage of the disease in such tubers than in those observed under field conditions.

Professor F. C. Stewart has kindly furnished us his notes on a potato disease observed at various localities in Ontario County as early as 1914. There was a distinct specking of the parenchyma of the stems in the vicinity of the nodes and cases were observed in which the shoots appeared to have died from the tip backwards. There was, however, no yellowing of the foliage nor cracking of the tubers although a necrosis of the vascular tissue of the tuber at the stem end was a rather constant accompanying symptom.

Growers who have been endeavoring to eradicate the disease by roguing affected plants are able to detect the disease on the vines at an early stage. These early symptoms were pointed out to the authors and were found to consist of a slight yellowing of the foliage at the apex of a branch with some rosetting. Frequently in such cases the terminal bud was dead even at this stage and plants were found occasionally whose tubers, while possibly normal in size, had already

cracked and, as sections revealed, showed the characteristic internal discolored areas of the disease. Often only one branch showed these symptoms, the ôthers appearing healthy. The cortex and pith of the affected branch showed, in most cases, the rusty specks in the upper nodes while the healthy appearing ones were free from them. The freedom of the lower portion of such affected branches from any appearance of disease would lead one to the conclusion that an infection had taken place above ground, from some outside source of inoculum, except for the presence of the symptoms in the tubers of such plants. Plants have been found in the latter part of the season showing these early symptoms which seems to indicate that no matter where infection occurs the tuber is not always the source of inoculum.

A large percentage of the tubers from affected plants are worthless for table stock or for seed. Plants affected late in the season produce some marketable tubers but even such of these as show internal discolorations usually are discarded. The percentage of affected plants in most fields that have been under observation is small however, ranging in most cases from a trace to 1 or 2 per cent. Some fields have shown 5 to 10 per cent and a few were observed where more than 20 per cent of the plants were affected. It can be seen that the disease may become serious. We do not know whether the larger area in which it has been found in 1920 represents a recent distribution or a failure to recognize it in preceding years. Efforts made by growers to eradicate it have been unsuccessful although they have kept it under control.

The writers have not carried out experiments to any extent to demonstrate the manner in which the causal agent, if any, is carried. They have been fortunate in being able to inspect a large number of variety tests conducted in various parts of the state in which a number of varieties of certified seed from different localities as well as a few local varieties have been planted in each test. Only one inspection of each test was made and the various tests were inspected at different times during the season. Table I shows the percentage of yellow dwarf found in each of the certified lots of each test. It seems reasonable to conclude from these data that the causal agent existed in the soil as the disease appeared in a majority of the lots in five tests located in counties where the disease has been found to be most prevalent while in the other localities where these same stocks were used the disease does not occur on any of them except in a few cases where a single variety was affected. The local varieties used in those tests where the certified stock showed the disease so generally had some affected plants in nearly every case. None were found among local varieties in the other tests except those in Steuben County. It should not be concluded from these data that the disease cannot be communicated with the seed. It

TABLE I—*Localities where yellow dwarf occurred and did not occur in eleven stocks planted in various localities in variety test 1921.*

County	Locality	Percentage of Yellow dwarf in stock from										
		Gardner & Son Tully Rur. Rus.	M. Porter Rodman Sir Walter Raleigh	M. Thompson Avoca Godson	C. C. Cornue Avoca No. 9	F. Gibbs Fillmore Hywt.	K. Livermore, Honeyoye Falls Rur. Rus.	S. Robinson Marathon Gr. Mt.	A. Reeves Lysander Green Mts.	O. Robson Hall Robson Seedling	E. Merihew Marathon Norcross	D. Nettleton Marathon Gr. Mt.
Fulton	Broadalbin	0	0	0	0	–	–	–	–	0	0	0
	Broadalbin	1.25	0	1.25	2.5	0	2.5	3.75	2.5	2.5	0	–
	Northampton	–	–	1	–	0	1	1	0		0	–
	Vail Mills	0	0	0	0	0	0	0	0	0	0	0
	Mayfield	–	3.5	5	1	0	0	2	6.5	.5	–	–
Green	Hunter	0	0	–	0	0	0	–	–	0	–	0
Jefferson	Adams	0	0	–	0	0	0	0	0	0	0	0
	Carthage	1	1	1	1	1	2	2	1	1	6	3
	Rodman	0	0	0	0	0	0	0	0	0	0	0
Lewis	Copenhagen	0	2	0	0	0	0	0	0	0	0	0
	Martinsburg	0	0	0	0	0	0	0	0	–	–	–
Ontario	Stanley	0	0	–	0	0	0	–	–	0	–	–
	Victor	0	0	–	0	0	0	–	–	0	–	–
	Naples	0	0	–	0	0	0	–	–	0	–	–
	Clifton Sps.	0	0	–	0	0	0	–	–	0	–	–
Saratoga	Ballston Lk.	0	0	–	0	0	0	0	0	0	0	0
	Saratoga Sps.	0	0	–	0	0	0	0	0	0	0	0

TABLE I (Continued).

County	Locality	Percentage of yellow dwarf in stock form										
		Gardner & Son Tully Rur. Rus.	M. Porter Rodman Sir Walter Raleigh	M. Thompson Avoca Goldson	C. C. Cornue Avoca No. 9	F. Gibbs Fillmore Hywt.	K. Livermore, Honeoye Falls Rur. Rus.	S. Robinson Marathon Gr. Mt.	A. Reeves Lysander Green Mts.	O. Robson Hall Robson Seedling	E. Merihew Marathon	D. Nettleton Marathon Gr. Mt.
Seneca	Lodi	2	0	–	0	0	0	–	–	0	–	–
	Waterloo	0	0	–	0	0	0	–	–	0	–	–
Steuben	Prattsburg	0	–	0	0	0	–	–	–	–	–	0
	Naples	0	–	0	0	0	–	–	–	–	–	0
	Arkport	1 5	–	–	0	0	0	–	–	–	–	–
	Arkport	–	–	0	0	–	0	0	0	0	0	–
	Bath	0	–	0	0	0	–	–	–	–	–	0
	Wheeler	–	0	0	0	–	0	0	0	1	0	–
	Savona	–	0	0	0	–	0	0	0	0	0	–
	Avoca	–	0	0	0	–	0	1	0	0	0	–
Tompkins	Brookton	0	0	–	0	0	0	–	–	0	–	–
	Freeville	0	0	–	0	0	0	–	–	0	–	–
Warren	Lake George	–	–	0	–	–	–	0	.5	–	1	.5
	Chestertown	–	–	–	.5	–	–	0	0	–	C	.5
Wyoming	Bliss	–	0	–	0	0	0	–	–	0	–	–
	Gainesville	–	0	–	0	0	0	–	–	0	–	–

TABLE II—*Percentage of yellow dwarf in certain rows as shown in variety tests conducted during 1921 in Washington, Franklin, and Suffolk Counties. All other rows showed no yellow dwarf.*

Location of test	Source of Seed		Row no.	Variety	Percent yellow dwarf
	Grower	Address			
W. W. Parish near Salem, N. Y. 23 sources of seed each except one duplicated, planted 100 hills to a row	Allan F. Hand	Greenwich, N. Y.	1	Dibbles Russet	1
	" "	" "	24	" "	1
	T. Cummings	" "	2	Rural Russet	1
	" "	" "	25	" "	1
	F. B. Nelson	Salem, N. Y.	5	Manistee	4
	" "	" "	28	"	5
	W. W. Parish	W. Rupert, Vt.	6	Sir Walter Raleigh	12
	" "	" "	29	" " "	4
	T. Cummings	Greenwich, N. Y.	8	Norcross	2
	" "	" "	31	"	1
	W. S. Collins	North Creek, N. Y.	15	Surprise	1
Allan F. Hand Greenwich, N. Y. 20 sources of seed planted in rows 137 ft. long	F. S. Hellenbeck	Tully, N. Y.	2	Rural Russet	1
	W. S. Collins	North Creek, N. Y.	5	Surprise	1
	A. F. Hand	Greenwich, N. Y.	9	Dibbles Russet	4
	P. Billings	" "	11	White Sprout	3
	F. B. Nelson	Salem, N. Y.	16	Manistee	2
	W. W. Parish	W. Rupert, Vt.	17	Sir Walter Raleigh	12

TABLE II continued

Location of test	Source of Seed		Row no.	Variety	Percent yellow dwarf
	Growers	Growers			
D. E. Martin Gabriels, N. Y. 24 sources of seed 100 hills of each planted in a row	Frank Delosh " "	Brushton, N. Y. " "	7 19	Carmen "	1 1
Morgan Topping Wainscott, N. Y. 62 sources of seed 1 pk. of each planted in test	Lake Placid Co. " " " M. Thompson " " Bruce Cottrell	Lake Placid Club, N Y. " " " " Avoca, N. Y. " " Homer, N. Y.	27 36 38 75 39	Green Mountain " " Goldson " Green Mountain	5 0 1 1 1
H. J. Reeves Mattituck, N. Y. 62 sources of seed 1 pk. of each planted in test	Lake Placid Co. " " "	Lake Placid Club, N. Y. " " " "	27 36	Green Mountain " "	3 5

is probable that it did not exist to any extent in the certified stock used, for it was selected stock in most cases and nearly all affected tubers, if such were present, would have been graded out before being shipped or upon cutting them at planting. Of course, it is possible that the causal agent could be carried with contaminated soil adhering to the tubers. It is known that the disease occurred to a slight extent in 1921 in the fields of Mr. Thompson at Avoca, N. Y., and may have existed in his stock in 1920. There is no record of its existence in the fields of those growing the other certified stock used in these tests. Soil and weather conditions are factors that may have some importance in connection with the appearance of the disease but they have not been considered here.

Attempts were made a number of times to determine whether affected tubers will produce affected plants. The smaller affected tubers have a tendency to dry rot within a month or two after digging and before the rest period is completed (Pl. VIII, fig. 4). Those that remained comparatively sound when planted in most cases either produced no sprouts or only feeble ones, the seed piece drying to a spongy brown mass. The vines that succeeded in coming through the ground were dwarfed and spindling, not having the symptoms described above as typical for the disease. These did not live long enough to produce tubers.

A few of the variety tests, however, gave indications that the disease is communicated with the tuber. Table 2 gives data to support this statement. One cannot examine such tests where certain stocks showed the disease in replicated rows while others did not, without believing that it was carried with the seed rather than that infection took place from the soil in which the seed was planted.

The ways and means of infection should not be difficult to determine but are not given because no serious effort has been made in this direction. For this reason, too, the writers are unable to present suggestions concerning the cause of the disease and the many other features of interest and importance in relation to it. Further observations may determine that it is but a different manifestation of symptoms produced by an organism already known as pathogenic to potatoes. It is thought desirable to present these observations now rather than wait until a complete study has been made in order that others may become aware of the existence and of the symptoms of the disease and may be on the lookout for it.

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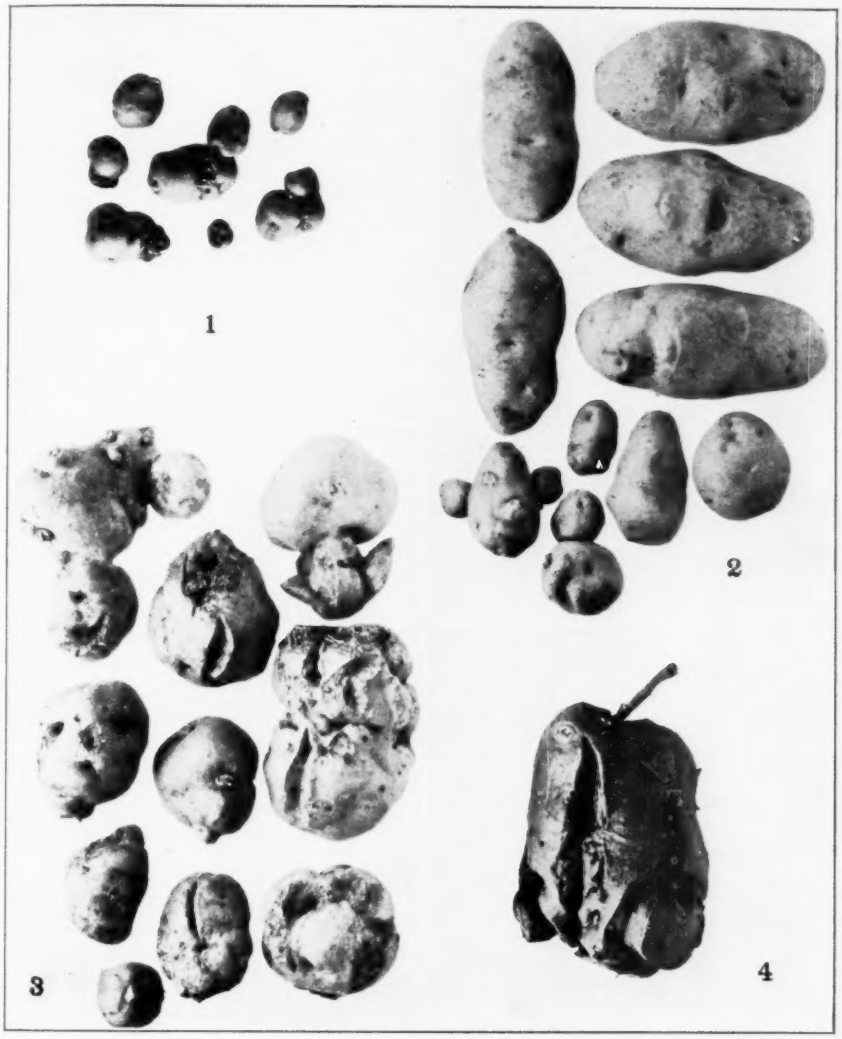

YELLOW DWARF OF POTATOES

FIG. 1. Yield from one badly diseased hill. No marketable tubers.

FIG. 2. Yield from a hill, a part of the vines being dwarfed. Five of the tubers are normal.

FIG. 3. Yield from one diseased hill. Each tuber shows cracking or other deformity.

FIG. 4. Severe, but characteristic cracking of a diseased tuber.

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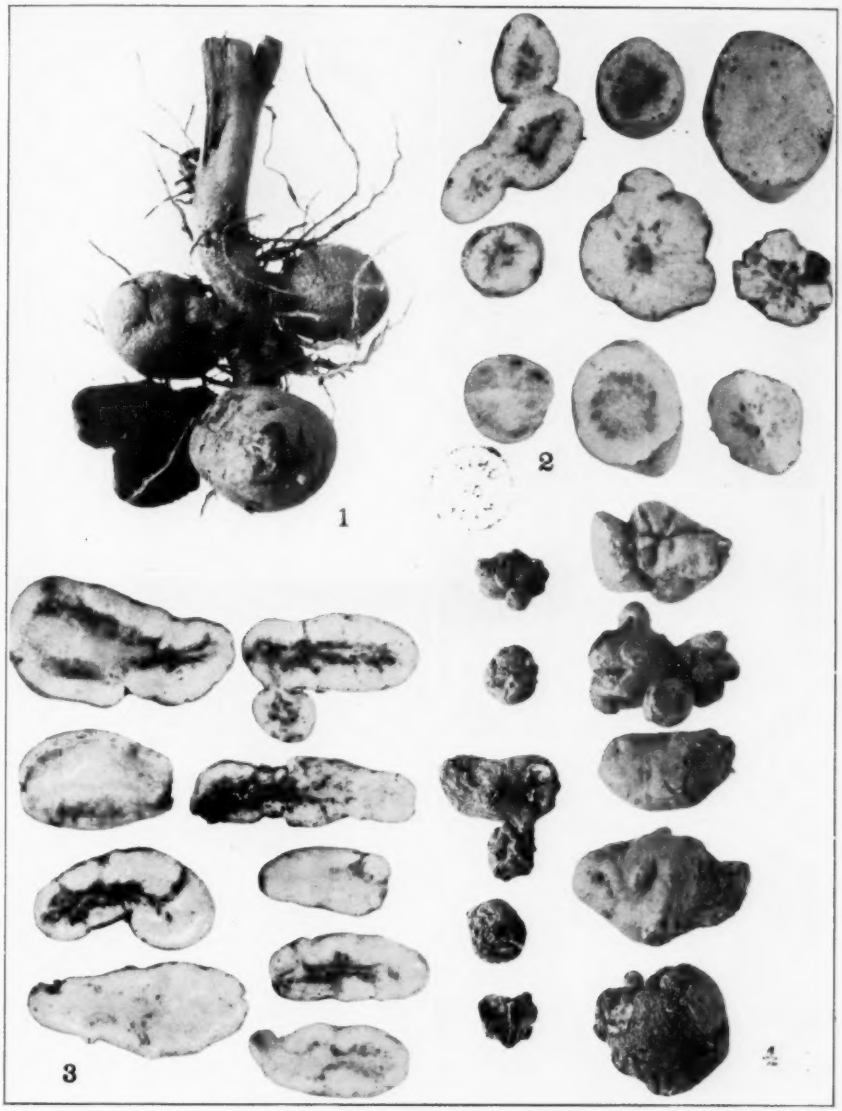

YELLOW DWARF OF POTATOES

FIG. 1. Basal part of a potato stem affected with yellow-dwarf. Observe the thick stem, sessile tubers and persistent seed piece!

FIG 2. Cross sections of tubers showing typical lesions of yellow-dwarf. Unlike the condition found in wilt, the discoloration is seldom found in the fibro-vascular bundles.

FIG. 3. Longitudinal sections of tubers similar to those in figure 2.

FIG. 4. Rot of tubers following yellow-dwarf.

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LEAF ROLL, MOSAIC AND CERTAIN OTHER RELATED DISEASES IN IDAHO

CHAS. W. HUNGERFORD

WITH PLATE IX

Potato leaf roll and mosaic have become of very great importance in various potato growing sections of the United States in the last few years. An examination of the Plant Disease Survey Reports of the United States Department of Agriculture reveals the fact that these diseases have not only caused more loss each year in the eastern states but also have been increasing to an alarming extent in the West. This reported increase may be due to a certain extent to the fact that they are becoming better known and more generally recognized, but there is very good evidence that these insidious diseases have spread very rapidly throughout the country.

Our records in Idaho show that both leaf roll and mosaic have gradually increased both in number of fields infected and in severity of infection during the three years since 1919, when records of the occurrence of these diseases in the state were first available. In 1919 the loss in Idaho from mosaic was estimated at one-half of one per cent., in 1920 at one per cent. and in 1921 at over three per cent. The same gradual increase seems to hold true for all of the potato producing states in the West.

When the writer first noted the mosaic disease in Idaho in 1919, it occurred on the variety known as the Netted Gem. There was some question as to whether the true mosaic was present. Mottling as it appears on the Bliss Triumph and on certain other varieties was not present. The characteristic crinkled and corrugated appearance, however, suggested mosaic. Schultz and others (8) have since listed the Netted Gem as among the varieties in which mosaic does not normally develop mottling. At the suggestion of Dr. I. E. Melhus, who visited the Idaho Experiment Station in 1919, progeny from several plants which had these symptoms were planted in the greenhouse. Under greenhouse conditions faint but unmistakable mottling appeared.

Numerous fields were also noted the same year in northern Idaho where from one to 20 per cent. of the plants showed unmistakable symptoms of leaf roll. As very little was known regarding the possible importance of these diseases in the northwest and the means by which they are disseminated under our conditions, some preliminary trials were made in 1920 with selected seed from various parts of the state.

FIELD TEST WITH LEAF ROLL AND MOSAIC

Tubers from plants infected with mosaic and from other plants showing the typical leaf roll condition were planted at Moscow on the experimental farm. Tubers from plants which were apparently healthy were planted as checks. The following table gives the results of these preliminary tests. Those in the series from C1 to C12 were from apparently healthy plants in fields where very little mosaic or leaf roll was found. C14, C15 and C16 were from apparently healthy plants taken

TABLE 1

Showing the source, variety, and yield of marketable tubers obtained from potatoes selected for seed from apparently disease-free and from mosaic and leaf roll plants

No.	Source	Variety	Number Hills Planted	Weight of Tubers		Ave. Wt. of Marketable Tubers per 10 Hills
				Marketable	Culls	
C1	Moscow	Netted Gem	13	19	0	15
C2	"	" "	41	44	5	11½
C3	"	" "	40	42	6	10½
C4	"	" "	30	54	4	18
C5	"	" "	28	43	2	17
C6	"	" "	22	39	3	17
C7	"	" "	21	33	3	16
C8	Troy	" "	20	30	4	15
C9	"	" "	34	53	2	15
C10	"	" "	34	51	4	15
C11	Rupert	" "	19	15	2	8
C12	Caldwell	" "	24	39	6	16¼
C13	Rigby	" "	22	18	4	8
C14	Moscow	" "	12	0	1	0
C15	"	" "	20	0	5	0
C16	"	" "	13	0	4	0
M1	"	" "	29	0	1	0
M2	"	Gold Coin	15	0	5	0
M3	Rupert	Betted Gem	9	6	2	6
M4	King Hill	Ida. Rural	5	0	3	0
M5	Rigby	Netted Gem	58	23	14	4
LR1	Moscow	Gold Coin	21	8	3	3½
LR2	"	Netted Gem	20	4	3	2
LR3	Princeton	" "	17	6	4	3½

from a field where from 75 to 80 per cent. of the plants were in the advanced stages of either mosaic or leaf roll. Those from M1 to M5 were selected from plants with definite mosaic symptoms. Those from LR1 to LR3 from plants in the early stages of leaf roll. Each number represents the tubers from one plant only, except in numbers M1, M2, M5, LR1, LR2 and LR3, where tubers from several hills having like symptoms were planted together. The source indicates the place in

the state where seed was secured. Caldwell, Rupert, Rigby and King Hill are in the irrigated section of southern Idaho. Moscow, Troy and Princeton are in the non-irrigated section of North Idaho.

It will be noted that in M1 although 29 hills were planted only one pound of cull tubers was harvested. These plants were very badly diseased and although the symptoms in the plants from which they were originally selected were clearly mosaic, the progeny showed symptoms of mosaic, leaf roll and curly dwarf. The one pound of culls from this lot was planted again in 1921, and practically no tubers were formed on any of the plants. The fact that C14, C15 and C16, which were apparently quite healthy plants selected from a badly diseased field, yielded no marketable tubers in 1920, and that all of the progeny in these three lots were badly diseased with either mosaic, leaf roll or both, would indicate that these diseases may cause very serious decrease in yield even the first year after infection has taken place.

RUSSET DWARF

Another potato disease which has been under observation in Idaho for the last three years and which appears to be somewhat similar to mosaic has been called russet dwarf. This disease was first called to the author's attention by Professor E. R. Bennett, Extension Horticulturist of the University of Idaho, in 1919. During that year the disease was noted in a large number of fields of Idaho Rural potatoes in Canyon County. In some fields as high as 35 per cent. of the plants were infected. This disease has previously been named and a brief description published (1, 2).

SYMPTOMS OF RUSSET DWARF

In the field, diseased plants have somewhat the appearance seen in certain types of mosaic. They are of a somewhat lighter green color than normal and only about two-thirds as large as healthy plants growing under the same conditions. The most conspicuous symptoms of infected plants as seen from some distance is the general rusty appearance of the leaves, especially the lower ones. In the more advanced stages of the disease many of the lower leaves fall off. A careful examination of the lower leaves of an infected plant reveals the fact that the veins of the lower side have a water soaked appearance in the earlier stages and finally turn brown. Death soon follows to a portion or all of the eaf and leaves fall off progressively from the ground up until in some

cases plants have been noted where the lower half of the plant was completely defoliated. Dark brown streaks are also present on the petioles and stems of the lower part of the plant. Later in the season the rest of the plant becomes affected and death of the entire plant often results. A careful check on the yield of healthy and diseased plants in the same field revealed the fact that the yield was reduced from one-half to two-thirds on the average. Plate IX, D shows a hill of Idaho Rurals affected with russet dwarf in comparison with a healthy hill.

When progeny from these diseased plants are grown in the greenhouse the symptoms noted above are much more striking and others appear which were not noted in the field. Diseased plants can be picked out as soon as they emerge from the ground. The first leaves are quite uniformly crimped or buckled downward at the tip. (Pl. IX, A). This characteristic is shown in all of the earlier leaves, some of them being so deformed as to be broader than long. Instead of the dwarfing which was noted in the field, the stalks often become elongated until they are sometimes several inches taller than healthy plants of the same age. (Pl. IX, E). The later leaves which develop are more normal in shape but are still somewhat crinkled. When the plants are four to five inches high, streaks with a water-soaked appearance begin to appear on the veins of the underside of the affected leaves. These streaks often start at the outer margin of the leaves extending in on the larger veins. They soon turn brown and a considerable portion of the veining on the under side of the leaf may become involved. Streaks of a similar nature may appear anywhere on the main stem or on the petioles of the leaves. Often a spot appears about half way up on the under side of the midrib where the leaf appears to be constricted. Frequently the midrib may crack at this point. Under greenhouse conditions the lower leaves begin to drop off rather early. The petiole of the affected leaf may become constricted near the stem and the leaf may fall before it has lost much of its green color. (Pl. IX, A). In some cases one-half of the leaf may be effected while the other half appears normal. This dropping of the leaves may take place progressively up the stem until only a rosette of leaves remains at the top. (Pl. IX, E). New growth sometimes starts at the axil of the leaf which has fallen. This in turn soon dies and drops off. (Pl. IX, B).

COMPARISON WITH OTHER DISEASES RECENTLY DESCRIBED

Murphy (4, 5) has recently reported a disease which he called leaf-drop which according to his description and photographs is very similar to russet dwarf. There are several points in which the symptoms of these two diseases do not agree, however. Murphy states that affected

plants are poorly covered with foliage and consist in the majority of cases of a single shoot. This is not the case with russet dwarf, in which there are the normal number of leaves and stems but on account of the reduced size of the leaves the plants often appear to have much less foliage. He also states that there is a slight browning of the vascular ring in the tubers from diseased plants. This characteristic has not been constantly associated with tubers from plants infected with russet dwarf. One symptom which is constant for russet dwarf, and which Murphy states is the one which separates leaf-drop from all other types, is the death and dropping of the leaves one after the other from the ground up. Murphy also states that the yield from plants diseased with leaf-drop is extremely low, being from one ounce to nothing at all per plant. This is not true of russet dwarf which we have noted under our conditions. In most cases the yield as stated above is reduced from one-half to two-thirds.

Russet dwarf also appears to have some characteristic in common with the disease which Murphy (4) has called crinkle, especially in the puckering and downward curling of the younger leaves as described above. In other ways it does not correspond at all with his description of this disease. Quanjer (6) also describes crinkle and speaks of this same characteristic. He also states that a bronze tinge prevails in some varieties affected with this disease. This description might apply to the characteristic russeting which appears in russet dwarf late in the season. Orton (7) in discussing the streak disease of potaotoes makes the following comment: "There is for example, a disease not uncommon in our trial grounds, marked by weak, erect stems, from which frequently the spotted leaves fall prematurely from the ground upward, so that a palm-tree like effect is produced." This description might well apply to russet dwarf as we have seen it in the greenhouse.

Krantz and Bisby (3) in discussing symptoms of mosaic state: "The lower part of the plant is often entirely defoliated in severe cases of mosaic dwarf in Minnesota." From the author's own observations in the Northwest and in the light of recent work, in Canada by Murphy and in Holland by Quanjer, it would seem that more than one disease has been described under the name mosaic in the United States.

TRANSMISSION OF RUSSET DWARF

It has been definitely shown that this disease is carried from year to year by means of tubers from diseased plants. This has been true in all of a large number of trials. Preliminary trials also indicate that the disease may be transmitted from plant to plant in the field. Idaho Rural potatoes were secured from a badly diseased field at Parma, Idaho, in 1919. Three lots of seed were secured. First, plants were

selected which were in the advanced stages of russet dwarf. Second, plants were selected which were adjacent to russet dwarf plants but which were themselves apparently free from the disease. In the third place, apparently healthy plants were selected which were at least five feet from any plants which were affected with russet dwarf. The first lot produced plants which were all affected with russet dwarf in 1920, the second produced plants which were over half of them affected, and the third lot produced plants over one-third of which were affected with the disease.

A grower in the northern part of Idaho secured seed from the southern part of the state from a field where there was a considerable amount of russet dwarf in 1919. In 1920 about 35 per cent. of the plants grown from this seed developed the disease. The grower rogued the field very carefully throughout the season and used the same seed another year. In 1921 about 15 per cent. of the plants developed the disease. It seems rather evident then that this disease as well as mosaic is infectious and that diseased plants may infect healthy ones in the field. Experiments are under way at the present time to learn if possible the agents which transmit the disease under Idaho conditions.

Numerous attempts have been made to isolate a causal organism from diseased plants. So far it has not been possible to prove the pathogenicity of any organism so isolated. A study of the pathological anatomy of diseased plants is also being undertaken.

CALICO

A condition which is locally known as "calico" is fairly common in irrigated sections of Idaho, Utah and Washington. Mention of this disease has already been made in two previous publications (1, 2). This disease is characterized by a pronounced variegation of the leaves of the plants. In extreme cases as much as half of the surface of the leaf may be almost entirely lacking in chlorophyll. The plants appear normal in every other way. Calico is much more pronounced early in the season many of the leaves appearing to develop chlorophyll in these chlorotic areas at about blossoming time. All evidence to date seems to show that this condition is inheritable but not infectious. Progeny from calicoed plants have in all cases produced plants with some of the leaves having this pronounced variegation. When tubers from plants showing this variegation were planted in the greenhouse, the symptoms which developed were similar to those noted in the field except that in some cases the chlorotic areas turned brown when the plants were about half grown. Later the whole leaf might become affected and the death of the leaf sometimes followed. Plate—, C shows a typical calico plant.

LEAF ROLL AND MOSAIC OF POTATOES

Fig. A. Idaho Rural potato plant showing early stage of russet dwarf in the greenhouse. Note curling at the tips of the leaves.

Fig. B. Idaho Rural potato plant affected with russet dwarf in the greenhouse. Note progressive dropping of the leaves from the ground upward and the new growth starting in axil of the lower leaves which have fallen.

Fig. C. Idaho Rural potato plant affected with calico. Note variegation on lower leaves in the foreground at X.

Fig. D. Healthy hill (at left) and russet dwarf (at right) under field conditions.

Fig. E. Healthy hill (at right) and russet dwarf (at left) under greenhouse conditions.

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The yield of tubers does not appear to be materially reduced by this disease and the amount of infection in any field observed has never been over 3 per cent.

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THE DISSEMINATION OF PEACH YELLOWS AND LITTLE PEACH.[1]

MEL T. COOK

These two diseases of the peach have been the subject of very earnest study for many years and although a great deal of important data has been accumulated we do not yet know either the causes of these two diseases or the methods by which they are disseminated. Furthermore, the symptoms are not well understood. It is very generally recognized by plant pathologists that very definite information on these three points is of the very greatest importance in developing satisfactory methods for the control of any disease.

For several years the writer has been cooperating with Prof. M. A. Blake and Mr. C. H. Connors of the Department of Horticulture of the New Jersey Agricultural Experiment Station in the study of these two diseases. The complete and detailed results of these studies have been published in bulletin number 356, January 1922. In these studies it was demonstrated that the budding of the nursery stock was one of the very important factors in the spread of these diseases. The nurserymen and the growers who bud their own stock practice two methods of securing their bud wood: 1 by selecting an apparently healthy bearing tree and 2 by budding from row to row, i. e. the taking of bud wood from vigorous young stock. A careful study shows that these diseases may be very readily distributed by either of the above methods. In the first case the nurseryman may make his selection for the purpose of securing stock of a certain variety or because he wishes to perpetuate a character which has appeared in some individual tree. The second method is followed because of its convenience and because it saves both time and labor, or because the nurseryman is satisfied with his stock and hesitates to make a new start.

In making studies of this kind it must be remembered that symptoms which are the same or similar to the recognized yellows and little peach symptoms may result from other causes: Some of the most common causes are 1, partial or complete girdling by borers, mice or other small animals; 2, injuries due to climatic factors, especially winter injuries at or just below the surface of the ground; 3, mechanical injuries, especially label wires which are sometimes left on the tree; 4, improper soil fertilization; 5, lack of proper cultivation; 6, other plant diseases especially those which cause partial or complete girdling; 7, unfavorable soil conditions; 8, defoliation due to improper use of sprays.

[1] Paper No. 63, of the Journal series, New Jersey Agricultural Experiment Stations, Department of Plant Pathology.

The studies of the author and his associates brought out the following points which are discussed more fully in the bulletin.

1. These diseases can be transmitted by using buds from diseased trees; the greater the severity of the disease in the scion tree, the more rapid its development in the young tree. The diseases can be transmitted by buds taken just before the development of the symptoms in the scion tree. The diseases can be transmitted by buds taken from apparently healthy branches of a diseased tree. The disease can be transmitted although the buds fail to grow. The disease can be transmitted by inserting a piece of bark from a diseased tree into a healthy one. In the case of June budding from a diseased tree, the disease does not develop until the second year. In one of our experiments a tree budded with yellows developed little peach.

2. Juices transferred from diseased to healthy trees did not carry the disease.

3. There is some proof that the disease is not carried by the pollen.

4. Pits from diseased trees very rarely germinate. It is very doubtful if the few that do germinate carry the disease.

5. The diseased are most likely to appear in orchards that have come into full bearing.

6. The diseases are likely to appear as epidemics.

7. The diseases are sometimes more severe on certain blocks of stock than on others.

8. The removal of a branch showing either of these diseases from a tree which is otherwise apparently healthy does not lead to the recovery of the tree although the tree may not show symptoms again until the second year following the removal of the branch.

9. These diseases are not equally prevalent every year. We had a very severe outbreak of yellows at the Vineland, N. J., experimental orchard in 1907 and a very severe outbreak of both diseases in 1919–20; in the latter outbreak the little peach was much more abundant than the yellows.

10. Blocks of trees of the same variety but from different nurseries do not develop these diseases to the same degree although planted side by side. Blocks of trees of the same variety and from the same nursery may develop different degrees of these diseases on different soil areas although separated by not more than one quarter of a mile.

11. The time and rate of incubation of these diseases dating from time of budding is not known. Trees budded from trees in which either of these diseases is very severe usually develop the disease the following year, while those budded from trees in which the disease is mild may not show symptoms for three, four or more years. Trees budded from a branch showing symptoms of either of these diseases will develop the

disease much more quickly than trees budded from the apparently healthy part of the same tree.

It will be readily seen from the above statements that although we do not know all the possibilities of transmission of these diseases, we do know that they can be readily transmitted by budding. We also know that the diseases may incubate as much as four years before the first symptoms appear. We also know that the early symptoms are very likely to be over-looked by those who have not made a special study of these diseases. It will be readily seen that it is possible for the most careful budder to select buds from diseased trees in which the symptoms are as yet not evident or only slightly developed. It will also be seen that young trees in the nursery may be diseased but not show the symptoms and that the row to row method of budding may result in carrying the disease from year to year and from old to new stock without the disease appearing in the nursery.

The fact that one or the other of these diseases sometimes develops in certain blocks of stock far in advance of other blocks in the same orchard leads the writer to suspect that nursery stock is sometimes a source of dissemination. Furthermore, growers sometimes take bud wood from trees which ripen their fruit a little early, thinking they have found an early variety and not realizing that the early maturity is a symptom of yellows. In cases of this kind, which have come to the writer's attention, the trees have developed the disease just as they were coming into bearing or very soon after.

The practice of the nurseryman cannot be criticised and the method of budding from row to row is commendable but these methods do not necessarily guarantee healthy stock. The trees from which the bud wood is taken should be kept under observation for a long period of time before the cutting of the bud wood so as to determine their characters and freedom from disease. They should be kept under observation and if any tree develops either disease within that time, the stock from that tree should be destroyed.

A few years ago the New Jersey Agricultural Experiment Station offered the nurserymen of the State bud wood from trees that had been kept under close observation from time of planting in the orchards. Several nurserymen accepted this offer. Of course, it has been impossible to follow these trees and we cannot give the results. Furthermore, the conditions arising from the world war made it necessary for us to discontinue the practice. Would a method of this kind followed out for a number of years, tend to reduce these diseases?

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COMPARATIVE SUSCEPTIBILITY OF EUROPEAN AND AMERICAN VARIETIES OF CUCUMBERS TO BACTERIAL WILT

S. P. Doolittle

In the course of an investigation of possible varietal resistance of cucumbers to cucurbit mosaic during the summer of 1921, a number of European and American varieties of pickling cucumbers were grown together at Madison, Wisconsin. The mosaic disease attacked all of these varieties with equal severity, but those from Europe proved extremely susceptible to bacterial wilt, *B. tracheiphilus* Erw. Sm., when compared to varieties grown in this country.

The plat used for this work was approximately one-half acre in size and had been used for cucurbit mosaic disease studies for the past five years, the disease being especially severe there each season. Bacterial wilt, however, had never caused serious losses prior to 1921. Seeds of commercial varieties of pickling cucumbers were obtained from Holland, France, and Germany, and planted in alternate rows with seeds of standard American varieties. As only a limited amount of the European seed was available, in some cases two of these varieties were planted in a single row, the foreign varieties being located in the center of the plat and several additional rows of American varieties at each end.

The planting was done on June 7, except rows 1 to 3, which were planted on June 20. The seeds were planted in drills in rows six feet apart, and the plants later thinned to a distance of fifteen inches. After the final thinning a record was made of the number of plants in each row, but; owing to the irregular shape of the plat and the uneven stand of plants in certain rows, no effort was made to secure a uniform number of plants per row. Bacterial wilt first developed about July 7, but no exact record was made of the wilted plants until July 18. After this date the plat was inspected at intervals of four to six days and records made of all plants which showed symptoms of bacterial wilt infection. The inspections were discontinued after August 18 as the combined attacks of mosaic and wilt made further detailed records of little value. The striped beetle, *Diabrotica vittata,* was present in considerable numbers throughout the season, being unusually numerous from June 15 to July 30. The insects were uniformly distributed over the plat and attacked all varieties with equal avidity. The following table shows the extreme variation in the amount of wilt on the European and American varieties.

TABLE 1. *Comparative susceptibility of European and American varieties of cucumbers to bacterial wilt.*

(European varieties with data in italics)

ROW *	VARIETY	NUMBER OF PLANTS	PRECENTAGE OF WILT AT DIFFERENT DATES				
			JULY 18	JULY 25	JULY 30	AUG. 6	AUG. 18
1	Heinz Pickling	110	0.0	0.0	0.5	3.0	22.0
2	Heinz Pickling	104	0.5	1.0	1.0	4.0	23.0
3	Heinz Pickling	111	0.0	1.0	5.0	13.5	23.0
6	Heinz Pickling	122	1.0	7.0	10.0	11.5	24.5
7	Heinz Pickling	124	1.0	5.0	8.0	12.0	23.0
8	Heinz Pickling	104	1.0	8.5	12.0	16.0	27.0
9	*Short Green Parisian*[1]	*50*	*4.0*	*26.0*	*40.0*	*80.0*	*90.0*
	Short Green Early[1]	*59*	*6.5*	*20.0*	*59.0*	*74.5*	*85.0*
10	Snow's Pickling	136	1.5	5.0	11.0	12.5	22.0
11	*Oblong Green Pickling*[2]	*62*	*7.0*	*47.5*	*59.5*	*77.5*	*94.0*
12	Snow's Pickling	113	1.5	6.0	9.0	11.5	37.5
13	*Half Long Prolific*[2]	*65*	*5.5*	*17.0*	*46.0*	*80.0*	*92.5*
	King William[2]	*59*	*6.0*	*16.5*	*39.0*	*84.0*	*100.0*
14	Fordhook Pickling	128	3.0	5.5	21.0	25.5	47.5
15	*Vert petit de Paris*[3]	*74*	*12.0*	*21.5*	*53.0*	*70.0*	*92.0*
	Cornichon de Meaux[3]	*54*	*6.5*	*22.0*	*43.5*	*76.0*	*93.0*
16	Fordhook Pickling	118	1.0	6.5	17.5	22.5	27.0
17	*Vert petit de Paris*[3]	*33*	*12.0*	*36.5*	*78.0*	*87.0*	*100.0*
	Cornichon de Toulouse[3]	*32*	*6.5*	*25.0*	*37.5*	*65.5*	*85.0*
19	Chicago Pickling	113	2.0	13.0	15.0	22.0	31.0
20	Fordhook Pickling	99	1.5	18.0	19.0	21.0	37.0
21	Jersey Pickling	99	0.5	9.0	9.0	15.0	30.0
22	Chicago Pickling	113	0.0	10.5	10.5	12.5	25.5
24	Chicago Pickling	96	1.0	18.5	19.0	23.0	33.5
25	Snow's Pickling	104	0.5	14.5	24.0	28.5	35.5
26	Heinz Pickling	90	1.0	12.0	12.5	13.5	33.5
27	Heinz Pickling	91	2.5	12.0	12.5	17.5	37.0
28	Heinz Pickling	66	3.0	12.0	12.5	16.5	41.0
Averages for American varieties			1.2	8.7	12.0	15.8	30.5
Averages for European varieties			7.6	25.8	50.6	77.1	92.4

* Rows 4, 5, 18, and 23, not planted to cucumbers.

[1] German

[2] Dutch

[3] French

It will be seen that all of the varieties from Europe showed a much greater percentage of wilt infection from the time the disease first appeared. On July 30, the average infection on the European varieties was approximately four times that on those of American origin. On August 18, but a few plants remained alive in the rows planted with

European seed, while the American varieties, although suffering considerable losses from the disease, would still have produced profitable crops were it not for the injury from mosaic. The high percentage of infection was strikingly uniform on all of the European varieties and consistently low in the case of those of American origin.

The data on wilt infection in this instance is complicated by the fact that mosaic was also spreading through the plat throughout the season. Although all of the plants were eventually affected, the spread of the mosaic disease was unusually slow and the infection was evenly distributed over all of the rows. Up to July 30, not over 8 per cent of the plants were mosaic diseased, and by this time the variation in susceptibility to wilt had been amply demonstrated.

The outbreak of bacterial wilt on this plat, which was somewhat isolated from other cucumber fields, was far more severe than any observed in other fields at Madison or at other points in Wisconsin and Illinois during the season. Bacterial wilt, however, was more severe in these states during 1921 than for several years previous, although serious losses occurred only in rare instances.

Additional evidence of the susceptibility of certain of the European varieties was secured in two other instances. The German varieties Short Green Early and Short Green Parisian, together with the varieties Oblong Pickling and King William from Holland, were planted in single rows adjoining a large block of the American variety, Heinz Pickling. The wilt was much less severe in this field, but approximately 40 per cent of the foreign plants were infected on August 20, as compared with an infection of less than 20 per cent on the American variety. On this date not over 1 per cent of the plants were mosaic diseased. A field of about one acre at Marengo, Illinois, planted with the foreign variety King William, showed an estimated infection of 15 per cent on August 9, while five fields in the vicinity planted with American varieties showed an average of less than 6 per cent.

It was noted that all of the European varieties were extremely susceptible to the hot, dry weather which prevailed during much of the summer, the older leaves developing a noticeable yellowing and curling toward the edges. This type of injury was found in nearly all fields in Illinois and Wisconsin, but was much more marked on the European varieties. These plants also wilted much more rapidly after infection than did those of the American varieties, the latter often showing evidence of local infections where the organism had seemingly failed to progress further. In the case of the European varieties, however, the infection nearly always seemed to involve the entire plant with considerable rapidity. It has seemed possible that plants produced from seed grown under the milder climatic conditions of western Europe might

be more susceptible to a disease of the wilt type when grown under the more intense heat and dry weather which prevailed in the Central States during the last season.

Although bacterial wilt is reported as occurring in Europe, the greater resistance of the American varieties may also be due partly to a greater prevalence of the disease in this country and a consequent development of comparatively resistant sorts through a gradual elimination of the more susceptible strains.

A NEW ALTERNARIA SPOT OF TOMATOES IN CALIFORNIA[1]

BRUCE DOUGLAS

WITH ONE FIGURE IN THE TEXT

In the fall of 1913 the writer first noticed a spotting of tomato fruit which was apparently distinct from other forms of tomato diseases that had been previously reported in California. This spotting has been noted in several localities in southern California but its study has been confined to the Whittier district, one five acre patch of tomatoes being studied carefully through two seasons.

The trouble appears soon after the first fall rains or heavy fogs and generally increases from then until the end of the season. On the fruit it is characterized by brown circular spots which become depressed as they increase in size. Later the surface of the spot is covered with a black velvety mass of Alternaria spores. The spots remain quite firm until secondary fungi and bacteria of a saprophytic nature enter, when the fruit goes down with a watery decay.

ISOLATION OF THE FUNGUS

In the fall of 1913 a species of Alternaria was isolated from the spots and by inoculation with spores similar spots were produced on sound fruit. In the fall of 1914 the fungus was again isolated fifteen different times from naturally occurring spots. Cultures obtained from plating out by the single spore method were used for the later inoculation eximents. For the isolation work Hiss media was used.

[1] The manuscript from which this brief account is extracted has been submitted with drawings and photographs to J. Rosenbaum and D. J. Mubraith, both of whom believe that the fungus as judged from the illustrations is neither *Macrosporium solani* nor *M. tomato*. Since the author of the paper is now a practising physician in Detroit and will not have opportunity to do further work on the disease, it is thought advisable to put this brief account of the work on record, with the suggestion that the disease may be different from any of those previously described on tomato.—H. S. Fawcett, Riverside, California.

In making cultures the following means were employed. (1) The skin of the fruits were flamed and pieces at the edge of diseased spots cut out and placed on the medium. (2) Other cultures were made from the fleshy part of the fruit under spots from which the epidermis had been cut away. The fungus was found at different depths varying from just under the epidermis to a little more than a quarter of an inch into the fleshy part of th fruit. (3) Still other cultures were made by drawing a sterile needle over the velvety mass of spores on the surface of a more mature spot. The fungus was readily obtained both from fruit fresh from the field and from that which had been placed in storage to ripen. The characters of spores of this fungus are shown in figure 1.

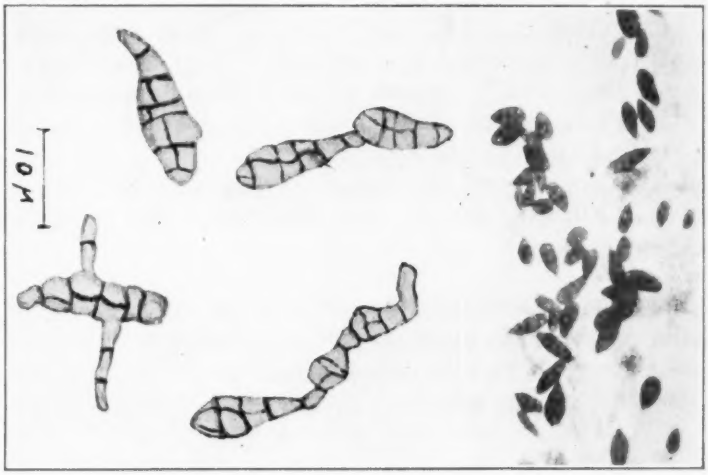

FIG. 1. SPORES OF AN ALTERNARIA FOUND ON TOMATOES IN CALIFORNIA

INOCULATION EXPERIMENTS

Inoculation experiments both on the fruit and on the foliage of the tomato were carried out. The method in which spores in large drops of water were placed on well sized green fruits just previous to the time they began to change color produced the most characteristic spots. Sterile water was added frequently during the first week so that the spores were not allowed to become dry. Inoculations of this character both in the open field and in moist chambers brought on spots in ten days to three weeks depending somewhat on the time it took the fruit to color and on the moisture conditions. Controls in which the same procedure was used with the exception that the spores of Alternaria were omitted, were allowed to remain for even longer than three week periods but in no case did spots appear where drops of

water without the spores had been placed. The Alternaria fungus was recovered in pure culture from a large number of artificially infected fruits but it was not found in the controls.

SPOTTING OF DETACHED LEAVES

Leaves from twenty-three varieties of tomatoes grown in the greenhouse were placed in moist chambers and sprayed with suspension of spores of this Alternaria fungus in sterile water. What appeared to be severe spotting from the Alternaria occurred with some varieties while others showed no effect. The fungus was reisolated from some of the spots. The varieties may be divided roughly into four groups according to the effects indicated at the end of three weeks.

Group I. Spotting severe: Beef Steak Los Angeles, Spark's Earliana, Stone, Trophy.

Group II. Spotting medium in amount: Acme, Beef Steak Whittier, Clark's Early Jewel, Crimson Cushion, Dwarf Champion, Dwarf Stone, June Pink, Livingstone's Favorite, Matchless, Perfection, Ponderosa, Yellow Peach, Yellow Pear, Yellow Plum.

Group III. Spotting slight: Beauty Livingstone, New Stone.

Group IV. No spotting: Atlantic Prize, Germain, Winter Queen, Golden Queen.

EXPERIMENTS IN THE INFECTION OF PINUS STROBUS WITH CRONARTIUM RIBICOLA

(A PRELIMINARY STATEMENT)

HAPLAN H. YORK AND WALTER H. SNELL

METHOD

About 500 potted seedlings of *Pinus strobus* of the seasons 1918 and 1921 were inoculated at North Conway, New Hampshire, in 1921. All of the inoculations were made in iceless refrigerators which were modifications of the one described by Hunt,[1] and which were placed near a small brook in a densely shaded swale in a pine woods. Freshly picked leaves of cultivated *Ribes nigrum* which bore an abundance of recently developed telia were used as a source of the inoculum.

Two methods of applying the inoculum were used, as follows: (1) The Ribes leaves as soon as gathered were supported 1 to 2 cm. above the needles of the seedlings on small sticks, before the telia had begun to germinate. (2) The telia were first allowed to germinate in moist chambers. The freshly gathered Ribes leaves were cut into pieces 1

[1] Hunt, N. Rex. The "iceless refrigerator" as an inoculation chamber. Phytopath. 9: 211–212. *Pl. 12.* 1919.

to 2 cm. x 1 cm. The pieces were then placed with the lower side upwards on a piece of ordinary window screen which was supported over a piece of absorbent cotton, saturated with water, in a covered Petri dish. When an abundance of sporidia had developed, the pieces of leaves were then lodged in the axils of the needles, of the seedlings. When the inoculations were made the seedling pines were placed in the refrigerators, sprayed with water and the inoculum applied. Then the plants were again sprayed with water and the refrigerators set in operation. During the entire time the seedlings were in the refrigerator droplets of water were present on the needles. After the seedlings were removed from the refrigerators, they were placed for a few days where they were shaded all day and then later moved to a garden where the pots were buried in the soil.

The temperature and humidity in the refrigerators were recorded by a properly checked Fries hygrothermograph. The latter was placed about 20 inches above the seedlings. The ground where they stood was thoroughly saturated with water. It is possible that the humidity in the immediate vicinity of the leaves was slightly higher and the temperature a little lower than where the hygrothermograph was located.

RESULTS

While it is not yet possible to give a full account of our inoculations enough evidence is already at hand to show that a large number of infections have occurred. The inoculated seedlings were examined November 21, 1921, by Dr. Perley Spaulding of the Office of Forest Pathology. He found typical yellow spots on the needles of 15 lots of the seedlings. A fascicle of needles from a 1918 seedling, No. 5299, and one entire 1921 seedling, No. 5317, were sent to Dr. R. H. Colley of the Office of Forest Pathology for examination. Colley has reported that the needles in both samples were thoroughly infected. In his report he states: "If anything, there are proportionately more individual infections in the needles of the 1921 seedling than in full grown leaves. In the former the spots were scattered generally along the whole length of the leaf." Eighty-five spots were counted on one needle of the 1918 seedling. The spots averaged about one per mm. in the infected areas. Substomatal vesicles were found in the leaves of the 1921 seedling. Both plants were from a series of 50 seedlings which were inoculated, beginning at 3:30 p. m. August 16, 1921. The inoculum was applied according to the method mentioned above. At the end of 38 hours, the Ribes leaves were destroyed and the seedling pines were removed from the refrigerators. During this time the average temperature and relative humidity in the refrigerators were respectively 65° F. and 94 per cent.

In a series of inoculations which were made on August 25, beginning at 2 a. m. the inoculum was applied according to the second method. At 2:30 p. m., 12½ hours later, on the same date, the inoculum was destroyed and the pine seedlings were removed from the refrigerator into the open air when the temperature and humidity were respectively 73° F. and 63 per cent for over one hour. The average temperature and relative humidity in the refrigerators during this experiment was 64° F. and 95 per cent.

At the beginning of this experiment, sporidia were removed from some of the pieces of leaves which were used for the inoculum and placed on needles of *Pinus strobus* which were then transferred to an empty iceless refrigerator where the temperature and humidity were 60° F. and 99 per cent. After one hour a few sporidia had begun to germinate.

No microscopic examination was made of the needles of the plants used in this series, yet yellow spots, which are typical of incipient infections, were present in great abundance. Such spots have not become visible in the controls. The latter consisted of 10 plants which were inoculated by scraping off telial columns with their sporidia and placing them on needles of plants which were left out in the open. The needles of the controls were slightly moist with dew. The plants were placed where they became fully exposed to bright sunlight about 8 a. m.

DISCUSSION AND SUMMARY

According to our observations which have been made in nature and on cultures of telia in damp chambers and in water, sporidia become fully developed from 5 to 6 hours after dry teliospores are brought under conditions favorable for their germination and the formation of sporidia. Considering this fact, together with the results of the second series of inoculations mentioned above, it might seem that at least 18½ hours of constant duration of such conditions of moisture and temperature as prevailed in our experiments are necessary for infection to occur on *Pinus strobus* in close proximity to Ribes on which sporidia are being produced.

Infection may occur within 12½ hours after the viable sporidia of *Cronartium ribicola* reach the needles of seedling *Pinus strobus* under such conditions of temperature and moisture as prevailed in the above mentioned experiments.

OFFICE OF INVESTIGATION IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

CELERY MOSAIC[1]

R. F. Poole

With Plate X and One Figure in the Text

In August 1921, our attention was called to some stunted and malformed Golden Self Blanching celery plants which were collected near Newark, New Jersey, by Mr. Nissley, Extension Vegetable Specialist who reported this condition to be severe on the farm from which the diseased celery was collected. Some time in September, Prof. Schermerhorn reported a similar case in his experimental plots at the College Station, where several varieties were growing together in the same field. The experimental field of celery was examined at this time and the characteristic symptoms of a typical mosaic disease were evident. The mosaic condition seemed especially severe on the Newark Market, a so-called easy bleaching variety.

Throughout the fall season there was very little rainfall, and the celery crop was no doubt suffering from the drouth. It was at first suspected that the mosaic symptoms of the plants might be caused by the unfavorable moisture conditions that existed at this time. It was assumed, however, that if the latter suspicion was correct, the celery plant which developes and produces new leaf shoots from a central heart, would in time overcome and outgrow the mosaic symptoms, if reset on a moist and fertile soil.

Given favorable temperature, moisture and cultural advantages, the malformed condition continued to appear on new shoots of diseased plants, the old leaves retaining their mosaic symptoms. Furthermore, the new leaves grown out from reset diseased plants in the greenhouse since October have been diseased more severely up to January 15 than were the larger branches which developed the symptoms in the field, demonstrating that the condition was not induced by lack of moisture, but was a true mosaic.

SYMPTOMS

The mosaic celery plants are very conspicuous, and readily distinguished from healthy ones. The entire plant is usually affected (Pl. X, fig. A). The foliage of the mosaic celery is sometimes drooping, wilting, or spreading. In most cases diseased foliage is nearly erect or straight becoming filiform and producing a bushy top (Pl. X, fig. B). As a general rule the leaves are shriveled and show numerous blister like pustules, which apparently do not burst, but affect the interior cell

[1] Paper No. 55 of the Journal Series. New Jersey Agricultural Experiment Station Department of Plant Pathology.

structure of the leaf to the extent of causing the malformation symptoms (Fig. 1). The diseased parts are very brittle, especially the young central branches. Force sufficient to pull up normal plants, will break off the tops of diseased plants, leaving the roots in the ground. There is no increased or decreased coloration observed in infected plants, either in the field or in the greenhouse.

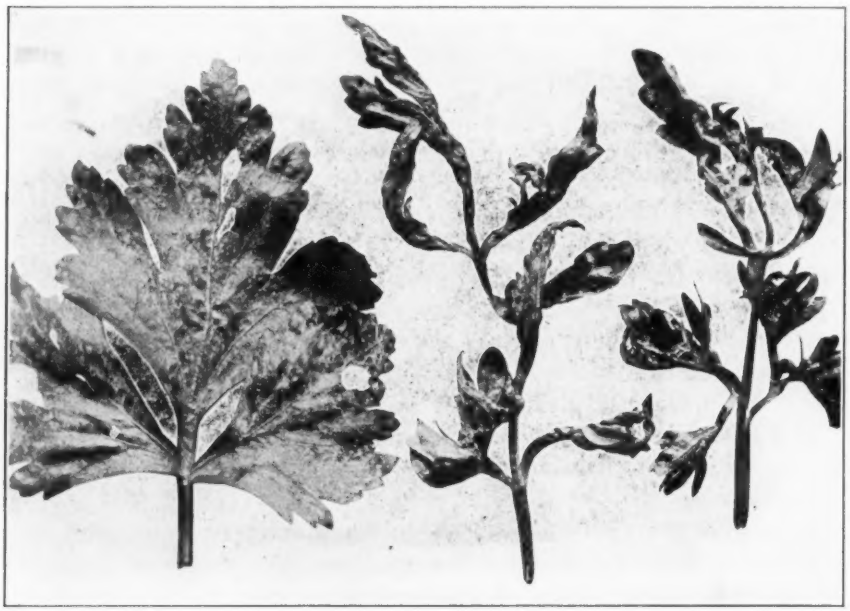

FIG. 1 COMPARISON OF MOSAIC LEAVES WHICH SHOW BLISTERLIKE PUSTULES, WITH A HEALTHY LEAF.

INOCULATIONS

In studying celery diseases for the last three years, no such mosaic plants or any conditions similar to this disease have been observed on celery in this state, although aphids (*Myzus persicae*) have been common and sometimes severe. It has been necessary to constantly fumigate in greenhouses, where celery was grown for other investigational work but even after severe aphid infestation in other years no such disease was observed.

Diseased plants set in the greenhouse in October have continued to grow and a large number of new leaves have been produced. The disease was noted on all the new shoots from the heart in their earliest stages of development. In all cases where diseased plants were protected from aphids the mosaic symptoms continued to develop on the young leaves as fast as they were produced. This may indicate that

the causal substances is also present in the heart and root portions of the diseased plants.

By infesting healthy plants with aphids from diseased plants, the symptoms of mosaic were demonstrated in two weeks on Golden Self Blanching celery. In less than a month following infestation, the blister like pustules were very prominent. After a sufficient number of plants had been inoculated and the mosaic symptoms had developed the aphids were killed by fumigation in order to determine if the disease symptoms would appear in the young leaves which developed after the aphids were killed. It was demonstrated that the mosaic symptoms not only persisted, but the new leaves which developed from October to January, were more severely diseased and the symptoms more characteristic on Golden Self Blanching celery than on the so-called green varieties.

There were a large number of single diseased plants in the field growing in contact with healthy ones. Observations conducted over a period of 4 weeks, during which there was no aphid infection, gave no indications that the disease was spread by contact. It is known that aphids were present on the celery at one time during the growing season. No definite data is available to show how many times the plants were attacked nor how prevalent the aphids were on any occasion.

VARIETAL INFECTION

The disease was found this year (1921) in a varietal experimental plot. This is of particular interest, since the sources of seeds are traced to three different seed companies, and as indicated in table 1 nearly all the popular commercial varieties of his section were found to be

TABLE 1—*Showing the percentage of diseased celery plants in commercial seed of different varieties*

No.	Variety	No. plants examined	No. plants diseased	% diseased plants
1.	Newark Market	100	9	9.0
2.	" "	100	24	24.0
3.	" "	200	27	13.5
4.	" "	70	8	11.4
5.	Giant Pascal	150	1 (?)	0.66
6.	Golden Self Blanching	291	34	11.6
7.	O. A. C. Yellow	81	10	12.1
8.	Winter Queen	86	0	0.0
9.	Columbia	90	4	4.4
10.	Noll's Magnificent	95	1	1.0

susceptible. It will be noted that in the first 100 plants examined in the Newark Market series, there were 9 diseased plants; while in the second 100 plants examined, there were 24 plants diseased. In the same plot, Giant Pascal, Golden Self Blanching, Oregon Agricultural College Yellow, Columbia, and Nolls Magnificent were also found to be diseased. Winter Queen was the only variety in which no disease was found. As is noted in the table, there is considerable variation in the infection of the different varieties. This may be due to lack of the spread of the infectious substance and not to resistance as the percentages of disease given in the table would indicate.

PROBABLE SOURCES OF INFECTION

For two years celery varieties have been tested on the same field plot. In 1920 the celery was examined in order to estimate the percentage of Cercospora and Septoria leaf spots in the different varieties. During that season, mosaic symptoms were not observed, but they occurred on the celery growing on the same soil in 1921. The seeds were germinated and seedling plants were grown in a greenhouse known to harbor the tomato mosaic. While there is yet no data to show that tomato mosaic is transmittable to celery, it might be added that such a relation seems probable since filiformed and mosaic tomatoes grew adjacent to the celery experiment in 1921. Investigations are in progress to determine if the disease can be transmitted by other means, to celery and other plants. The relation of the disease to seed production and transmission by seeds is being studied. Since several months will be required to satisfactorily complete these details, it is thought advisable to present these data at the present time with the hope of throwing more light on the subject in a later paper.

The writer wishes to acknowledge suggestions from Dr. Mel T. Cook in connection with these studies.

AGRICULTURAL EXPERIMENT STATION
NEW BRUNSWICK, N. J.

CELERY MOSAIC

FIG. A. A Mosaic Celery Plant.
FIG. B. Filiform and Mosaic leaves.

UNIV. OF MICH.

PHYTOPATHOLOGICAL NOTES

The relation of rain to the formaldehyde treatment of onion smut. The object of this note is to emphasize a precaution that should be observed in applying formaldehyde for the control of onion smut.

During the spring of 1920, two onion-set growers in north western Indiana, co-operating with the Extension Department at Purdue University, used the formaldehyde drip method for the control of onion smut. The apparatus used was the type recommended by Walker (U. S. Dept. Agric., Farmers' bulletin 1060), consisting of a three gallon tank having a three-eighth's inch pipe to conduct the formaldehyde solution to the seed in the furrow. The solution used was made up at the rate of one pint of formaldehyde in sixteen gallons of water.

The treatment was successful in one case but much less so in the other. In the first field where white onions were grown 271.6 bushels per acre was the yield from the treated plots and 177.6 bushels from the untreated plots, an increase of 94 bushels per acre. In the second field the increase in yield due to the treatment was 60 bushels per acre in white onions and 20 bushels per acre in red onions.

The soil in each case is the same, a black sandy loam. Both growers have been raising onion sets for about the same length of time and there is no evidence that there is any variation in the degree of soil infestation by the smut in the locality. The most outstanding variant in these two cases was that of the weather conditions at the time of planting and subsequently.

In the first case where the results of the treatment were most satisfactory, the planting was done during the week of May 4. The grower was delayed in his sowing till this time by the continued rains of April. There was no rain during the first ten days of May. On the eleventh, twelfth and thirteenth there was a little more than an inch and on the seventeenth, eighteenth and nineteenth, nine-tenths of an inch more fell. It was six days after the onions were planted before it rained.

In the second case the grower planted his onions on Monday, April 26th. During the two weeks previous to the day of sowing 3.3 inches of rain fell in nine days. On the day that the seed was sown and the formaldehyde applied 0.28 inches fell as a light drizzle throughout the day. It also rained on April 27, 28 and 30. The total for these four days was 1.17 inches. In April there were 5.67 inches of rain in this region as compared with 2.01 inches in May.

One explanation of why the treatment was not successful in the latter case seems to be the frequent rains. It may be that the formaldehyde was rapidly leached away from the furrow containing the seed,

or diluted and not given an opportunity to disinfect. It may be possible also that the increased water content of the soil may have prevented the most efficient permeation of the soil by the gas and so greatly restricted the area of disinfection. Whatever the explanation, it would seem that the application of formaldehyde will not be as effective if made during rainy periods.—C. T. GREGORY.

Crop Protection Institute fellowships. In order to promote original research relative to the fungicidal and insecticidal properties of sulphur and the effects of sunlight, temperature and moisture on its action, the Crop Protection Institute expects to offer two fellowships yielding an income of $2500.00 each. Training in chemistry and plant physiology is a prerequisite, and candidates should have demonstrated ability to undertake research efforts of a high type. Applications, accompanied by reprints of scientific articles and letters of recommendations, should be made immediately to the Crop Protection Institute, National Research Council, Washington, D. C. A statement explaining the purposes and scope of the projects and selection of research laboratory may be obtained on application.—W. C. O'KANE.

Personals.—Dr. P. J. Anderson of the Department of Botany, Massachusetts Agricultural College, has been transferred from the teaching staff of the college to be Research Professor of Botany in the Experiment Station. Dr. W. H. Davis of the University of Wisconsin has been appointed to the position made vacant on the teaching staff.

H. Atherton Lee, Mycologist, of the Department of Agriculture and Natural Resources, Government of the Philippine Islands, Manila, has accepted the position of Director of the Sugar Cane Investigations of the Philippine Sugar Centrals. Mr. Lee maintains his connections with the Bureau of Science as Mycologist.

Mr. Arthur C. Foster, formerly Extension Plant Pathologist for the North Carolina Agricultural College, was appointed Assistant Pathologist in the Bureau of Plant Industry January first. He is stationed at Sanford, Florida, where he is working in association with Dr. I. C. Jagger on diseases of lettuce, celery, and other Florida truck crops grown for the northern markets.

Mr. W. B. Tisdale of the University of Wisconsin recently accepted a position with the Florida Agricultural Experiment Station, Gainesville, where he is engaged in investigations of tobacco diseases.

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